Advertising and U.S. Nonalcoholic Beverage Demand

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As a first effort at modeling nonalcoholic beverage demand in a systemwide framework that includes bottled water, this article examines the impact of advertising on the demand for nonalcoholic beverages in the United States. We employed an AIDS (almost ideal demand system) model of five jointly estimated equations that included advertising expenditures as explanatory variables to evaluate annual U.S. consumption of nonalcoholic beverages for 1974 through 2005. Results suggest that advertising increases demand for fluid milk, soft drinks, and coffee and tea, but not for juice or bottled water. Advertising spillover effects occur in over 50 percent of the cases considered, and such effects can be substantial, particularly for advertising of soft drinks, and coffee and tea. We find that a large increase in the retail price of fluid milk, an increasing trend towards dining out, and positive spillover effects from soft-drink advertising made significant contributions to bottled water's success in recent years.

Key Words: advertising, demand, elasticity, nonalcoholic beverages

This research investigates the impact of advertising on nonalcoholic beverage demand in an integrated framework with a focus on impacts from cross-commodity advertising, commonly known as spillover effects. To achieve this objective, we jointly estimated five demand equations in a system that included advertising expenditures as explanatory variables to evaluate annual U.S. consumption of nonalcoholic beverages—fluid milk, juice, soft drinks, bottled water, and coffee and tea—for 1974 through 2005. Empirical estimates of own- and cross-beverage advertising elasticities are obtained, as are compensated price elasticities, uncompensated own-price elasticities, and expenditure elasticities.

Although the nonalcoholic beverage industry spends an average of $2 billion per year (as of 2005) on advertising—making these beverages one of the most heavily advertised commodities in the United States—little research has investigated the spillover effects of that advertising within an integrated framework. Spillover refers to the cross-commodity impacts of advertising. For example, if an increase in milk advertising increases milk demand and at the same time decreases bottled-water demand, the decrease in bottled-water demand lowers the price of bottled water, which tends to erode the demand for milk due to second-round or "feedback" effects (Kinnucan and Zheng 2005, p. 276). Therefore, failing to take these spillover effects into account tends to generate results that overstate returns from advertising and only partially measures the advertising impact. Estimating returns to advertising with control of spillover effects is especially important for commodities such as milk and juice that have been the targets of significant levels of generic advertising. An accurate estimate of the return on advertising of these commodities is crucial in determining optimal spending levels for such programs.

Despite bottled water's significant stature and its unparalleled and continuing growth, advertising's impact on its demand has not received the same degree of attention as for other nonalcoholic beverages. Per capita consumption in the United States of nonalcoholic beverages in recent years has been characterized by a decline for milk and coffee, a steady rise for soft drinks, and dramatic growth for bottled water. For example, per capita bottled-water consumption increased from 11.6

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gallons in 1995 to 25.4 gallons in 2005, topping consumption of milk and coffee (21.0 and 24.2 gallons, respectively). Meanwhile, expenditures on bottled-water advertising increased twenty-fold, from $7.8 million to $158.9 million. So far, bottled water's success has been seen as "driven primarily by heightened consumer demand for healthier beverage alternatives and greater convenience" (Beverage Marketing Corporation 2006, p. 47). The question of whether the substantial increase in advertising of bottled water has contributed to its success remains unanswered.

Spillover effects are properly evaluated in multi-equation demand systems such as the Rotterdam model and almost ideal demand systems (AIDS) rather than with single-equation demand models. For example, from a single equation for milk demand we can learn whether juice advertising affects milk demand but not whether milk advertising affects juice demand unless we specify an additional demand equation for juice.

For alcoholic beverages, it is common practice to model demand for beer, wine, and spirits in a system that scrutinizes the own- and cross-beverage impacts of advertising on demand [see Duffy (1995) for the United Kingdom, and Nelson and Moran (1995) for the United States]. The effects of advertising on demand for nonalcoholic beverages, however, have been estimated mostly using single-equation demand models [see Kaiser (1997) for milk, Schmit and Kaiser (2004) for milk, Lee and Brown (1992) for juice, and Nelson, Siegfried, and Howell (1992) for coffee], in a demand system for a subgroup of beverages [see Gao and Lee (1995) for three different juices], or in a demand system that also included alcoholic beverages [see Lariviere, Larue, and Chalfant (2000) for soft drinks].[1] Virtually no studies exist on the effects of advertising on demand for tea or bottled water alone.

Only two studies (Kinnucan et al. 2001, Yen et al. 2004) are available in the literature that model nonalcoholic beverage demand using a systemwide approach. Both studied the U.S. market and excluded bottled water. Using a two-stage Rotterdam model, Kinnucan et al. (2001) found that advertising redistributed demand within the nonalcoholic beverage group rather than effectively enlarging demand for nonalcoholic beverages. Specifically, they found that coffee and tea were most affected by advertising of other beverages and that milk was least affected. Juice advertising exerted the largest influence within the nonalcoholic beverage group. Only juice had a positive and statistically significant own-advertising elasticity. Yen et al. (2004) incorporated prices, incomes, and demographic variables—including nutrition information, dietary beliefs, race, and age—to estimate household beverage consumption in a translog demand system. Advertising, however, was not included. Note that the data used by Kinnucan et al. (2001) were for 1970 through 1994. The present study incorporates bottled water and employs more recent data. This paper endeavors to fill the current void in studies addressing the effectiveness of bottled-water advertising and of advertising spillover effects within the contemporary nonalcoholic beverage industry in a systemwide framework.

Model

The AIDS model developed by Deaton and Muellbauer (1980) was selected because it has many desirable properties, including the ability to provide an arbitrary first-order approximation for any demand system and exactly satisfy the axioms of choice, and the simplicity of its estimation.

We posited the following linear approximation version of the AIDS model (LA/AIDS model) to fit the time-series data:

(1)
$$w_{it} = a_i + b_i \ln(Y_t / P_t) + \sum_{j=1}^{5} c_{ij} \ln p_{jt} + \sum_{j=1}^{5} d_{ij} \ln A_{jt} + e_i \ln Age5_t + f_i \ln Fafh_t + \varepsilon_{it},$$

where i (=1, 2, 3, 4, 5) indexes the five beverage categories in the nonalcoholic group in order as fluid milk, juice, soft drinks, bottled water, and coffee/tea; t indexes year; p_{jt}, q_{jt}, and A_{jt} are nominal price, per capita consumption, and real advertising expenditures for item j in year t; $Y_t = \sum_{i=1}^{5} p_{it} q_{it}$ is the nominal group expenditure; w_{it} is the (conditional) budget share of item i in year t where $w_{it} = p_{it} q_{it} / Y_t$; P_t denotes Stone's geometric price index ($\ln P_t = \sum_{i=1}^{5} w_{it} \ln p_{it}$); $Age5_t$ is

[1] Nelson, Siegfried, and Howell's (1992) coffee study endogenized the brand's advertising behavior.

the proportion of the U.S. population less than five years of age in year t; $Fafh_t$ is food-away-from-home expenditures as a proportion of food expenditures in year t; a_i through f_i are the parameters to be estimated; and ε_{it} is the error term for item i in year t. The system we estimated is conditional on U.S. expenditures on nonalcoholic beverages as a group with the implicit assumption that nonalcoholic beverages are a weakly separable group.

The inclusion of $Age5_t$ and $Fafh_t$ is to account for the impacts of demographics on nonalcoholic beverage demand. Previous research showed that the proportion of population under age five or six was a significant factor in explaining milk consumption (e.g., Kinnucan et al. 2001, Schmit and Kaiser 2004, Kaiser 2006). Following Kinnucan et al. (2001), we also included $Age5_t$ in the other four equations to maintain the singularity of the demand system. The use of $Fafh_t$ captures the impact of eating habits on nonalcoholic beverage consumption. The proportion of food-away-from-home expenditures increased from one-third to one-half almost monotonically during the period 1974–2005. The use of $Fafh_t$ in the model, therefore, informs us how the increasing trend of dining out affected consumers' choice regarding nonalcoholic beverages. Our expectation is that more dining-out increased demand for soft drinks and decreased demand for milk. Furthermore, since the correlation between $Fafh_t$ and a linear time trend (0.97) is almost perfect, we don't need to specify an additional trend term for the model. As a result, the coefficient estimate of $Fafh_t$ may also capture other factors that are closely correlated with the time trend, e.g., consumer preference for healthier beverages. Therefore, the coefficient estimate of $Fafh_t$ should be interpreted with the above caveat in mind.

Data

The model was estimated using annual time-series data for the United States for 1974 through 2005. Less aggregated data such as state-level panel data or quarterly data were not available.[2] The price and quantity data were obtained from two government sources: the *CPI Detailed Report* from the U.S. Bureau of Labor Statistics (the price of bottled water was obtained from Beverage Marketing Corporation) and the *Food Availability (Per Capita) Data System* from the Economic Research Service (ERS) at the U.S. Department of Agriculture. Soft drinks and juice refer specifically to carbonated soft drinks and fruit juice. Data on *Age*5 and *Fafh* were obtained from ERS as well. The advertising data were obtained from private sources, chiefly *Ad $ Summary* published by Leading National Advertisers, Inc., and *AdView*, an advertising tracking program maintained by AC Nielsen. Milk advertising in this case was strictly generic advertising. Juice advertising combined generic and brand advertising. Advertising for the other three beverage categories was all brand advertising. A media cost index (2004 = 100), which was computed from annual changes in promotion and advertising costs by media and provided by Dairy Management Inc., was used to deflate the advertising figures. A more complete description of the data, including sources, is available in Kinnucan et al. (2001, pp. 24–28) and Zheng, Kinnucan, and Kaiser (2008). Definitions of variables and summary statistics for the data are reported in Table 1.

Estimation and Parameter Estimates

The model was estimated using the PROC MODEL procedure in SAS 9.1. Given that we estimated a conditional demand system using time-series data, the potential presence of group-expenditure ("expenditure" for short) endogeneity and serial autocorrelation is necessarily examined (see LaFrance 1991, Thompson 2004). The endogeneity of expenditure was examined using $\ln(Inc_t/P_t)$ and a linear trend variable as instruments for $\ln(Y_t/P_t)$ where *Inc* is per capita personal income obtained from the U.S. Bureau of Economic Analysis. Our testing procedure is similar to that used by McGuirk et al. (1995, p. 17). The Wald statistic for the null hypothesis that the expenditure is exogenous was not statistically significant at the 5 percent level (default level in this paper).

The Godfrey's serial autocorrelation test indicated the existence of autocorrelation; we therefore estimated the LA/AIDS model with an AR (1) process:

$$(2) \qquad \varepsilon_{it} = \rho_{i1}\varepsilon_{i,t-1} + u_{it},$$

[2] Quarterly data were available for price, advertising, *Age*5, and *Fafh*, but were not available for consumption.

Table 1. Variable Definitions and Summary Statistics, 1974–2005

Variable	Definition	Mean	Minimum	Maximum	*s.d.*
q_1	Per capita fluid milk consumption, gallons/person	25.35	20.98	29.50	2.54
q_2	Per capita juice consumption, gallons/person	7.91	6.15	9.10	0.84
q_3	Per capita soft-drink consumption, gallons/person	43.98	27.60	53.80	8.41
q_4	Per capita bottled-water consumption, gallons/person	9.41	1.26	25.43	6.99
q_5	Per capita coffee/tea consumption, gallons/person	33.37	28.16	40.62	2.72
p_1	Nominal retail price for fluid milk, $/gallon	2.16	1.23	3.34	0.61
p_2	Nominal retail price for juice, $/gallon	3.67	1.50	5.26	1.16
p_3	Nominal retail price for soft drinks, $/gallon	1.66	0.83	2.11	0.35
p_4	Nominal retail price for bottled water, $/gallon	1.06	0.70	1.36	0.19
p_5	Nominal retail price for coffee/tea, $/gallon	0.84	0.33	1.12	0.20
A_1	Advertising expenditures for fluid milk, million $ in 2004 $	56.06	9.77	160.57	42.81
A_2	Advertising expenditures for juice, million $ in 2004 $	244.12	31.33	730.42	148.34
A_3	Advertising expenditures for soft drinks, million $ in 2004 $	422.78	97.00	807.77	197.77
A_4	Advertising expenditures for bottled water, million $ in 2004 $	34.04	6.97	158.92	39.11
A_5	Advertising expenditures for coffee/tea, million $ in 2004 $	215.71	73.86	340.45	61.49
w_1	Budget share for fluid milk, conditional	0.28	0.23	0.44	0.05
w_2	Budget share for juice, conditional	0.15	0.11	0.17	0.02
w_3	Budget share for soft drinks, conditional	0.37	0.28	0.42	0.04
w_4	Budget share for bottled water, conditional	0.05	0.01	0.12	0.03
w_5	Budget share for coffee/tea, conditional	0.15	0.11	0.23	0.03
Fafh (%)	Food-away-from-home expenditures / total food expenditures	43.45	34.10	48.49	4.16
*Age*5 (%)	Proportion of the U.S. population younger than age five	7.25	6.78	7.71	0.29

where ρ_{i1} is the first-order autoregressive parameters and u_{it} is a white-noise disturbance. Finally, a White's test for heteroscedasticity was not statistically significant for any of the five equations.

Because $\sum_{i=1}^{5} w_i = 1$, the following adding-up conditions are met automatically, implying that only four equations are necessary to estimate the system:

$$(3) \quad \sum_{i=1}^{5} b_i = \sum_{i=1}^{5} c_{ij} = \sum_{i=1}^{5} d_{ij} = \sum_{i=1}^{5} e_i = \sum_{i=1}^{5} f_i = 0 \quad \text{and} \quad \sum_{i=1}^{5} a_i = 1.$$

The juice equation was dropped in the estimation and its parameters were calculated using the adding-up restrictions. In the presence of autocorrelation, the iterative, seemingly unrelated regression (ITSUR) is not maximum likelihood (Seale, Marchant, and Basso 2003) and, therefore, the full-information maximum-likelihood method (FIML) was used to fit the model. Furthermore, given limited degrees of freedom in the data, the model was estimated under the assumption that the equations share a common auto-regressive parameter. The model satisfies the multivariate normality assumption as indicated by the Henze-Zirkler T statistic.

The AR (1) LA/AIDS model was estimated with price homogeneity and symmetry imposed as maintained hypotheses. The FIML parameter estimates are reported in Table 2. The results were satisfactory in that the adjusted R^2's ranged from 0.86 for the juice equation to 0.99 for the

Table 2. FIML Parameter Estimates of Conditional Demand Equations for U.S. Nonalcoholic Beverages, 1974–2005

	Price Coefficients					Advertising Coefficients				
EQUATIONS	c_{i1}	c_{i2}	c_{i3}	c_{i4}	c_{i5}	d_{i1}	d_{i2}	d_{i3}	d_{i4}	d_{i5}
Milk	0.146**					0.006**	0.012**	-0.037**	0.005**	0.027**
	(0.012)					(0.002)	(0.004)	(0.007)	(0.002)	(0.004)
Juice	-0.060**	0.103**				0.002	-0.002	0.010	-0.011**	-0.015**
	(0.014)	(0.029)				(0.003)	(0.007)	(0.012)	(0.003)	(0.006)
Soft drinks	-0.108**	0.027	0.177**			0.005	-0.020**	0.022**	-0.001	0.00001
	(0.011)	(0.019)	(0.019)			(0.003)	(0.006)	(0.010)	(0.003)	(0.006)
Bottled water	0.076**	-0.044**	-0.078**	0.045**		-0.004	0.003	0.036**	0.005	-0.029**
	(0.009)	(0.014)	(0.012)	(0.014)		(0.003)	(0.006)	(0.011)	(0.003)	(0.006)
Coffee/tea	-0.054**	-0.026**	-0.018	0.002	0.096**	-0.009**	0.006	-0.031**	0.002	0.017**
	(0.006)	(0.010)	(0.009)	(0.009)	(0.010)	(0.003)	(0.007)	(0.011)	(0.003)	(0.006)

	Intercept	Expend.	*Age5*	*Fafh*	Adj. R^2
EQUATIONS	a_i	b_i	e_i	f_i	
Milk	1.663**	-0.093**	0.071**	-0.296**	0.99
	(0.167)	(0.041)	(0.029)	(0.033)	
Juice	0.525	-0.052	-0.129**	0.025	0.86
	(0.273)	(0.064)	(0.044)	(0.059)	
Soft drinks	-1.166**	-0.001	0.124**	0.321**	0.97
	(0.220)	(0.061)	(0.041)	(0.045)	
Bottled water	-0.510**	-0.112	-0.039	0.295**	0.96
	(0.206)	(0.061)	(0.042)	(0.045)	
Coffee/tea	0.487**	0.259**	-0.026	-0.345**	0.96
	(0.196)	(0.061)	(0.044)	(0.042)	

Note: ** denotes that estimates are significant at the 5 percent level or less. Standard errors are in parentheses.

milk equations, all of the own-price coefficients and seven of the ten cross-price coefficients were statistically significant, and fourteen of the twenty-five advertising coefficients were significant. The variable *Age*5, which is the proportion of the population under age five, was found to be positively related to milk and soft-drink consumption but negatively related to juice consumption. The variable *Fafh* was found to be statistically significant for all beverages except juice, with signs indicating that more dining out leads to increased consumption of soft drinks and bottled water at the expense of milk and coffee/tea.[3]

Elasticities

Based on the information in Table 2, we computed the expenditure, own-price, cross-price, and advertising elasticities from formulas derived in the literature as follows:

(4) $$E_i = 1 + b_i / w_i$$
(expenditure elasticity)

(5a) $$E_{ii}^C = -1 + c_{ii} / w_i + w_i$$
(compensated own-price elasticity)

(5b) $$E_{ij}^C = c_{ij} / w_i + w_j$$
(compensated cross-price elasticity)

(5c) $$E_{ii}^U = -1 + c_{ii} / w_i - b_i$$
(uncompensated own-price elasticity)

(6) $$\alpha_{ij} = d_{ij} / w_i$$
(advertising elasticity).

All were conditional elasticities in that they were computed under exogenous group expenditures. The compensated elasticities measure pure substitution effects, and obtaining their standard errors, which involves only one parameter estimate, involves less complicated computation than the uncompensated ones. Calculated elasticities are given in Table 3. These elasticities were calculated based on the (conditional) budget share for nonalcoholic beverages in 2005. Because E_{ii}^U involves two parameters, its standard errors were derived using the Delta method.

Conditional Expenditure and Price Elasticities

All of the own-price elasticities (compensated and uncompensated) were negative and less than one (inelastic). The beverages that had the highest and lowest compensated price elasticities were bottled water at -0.498 and coffee/tea at -0.083. The uncompensated own-price elasticities are larger than the compensated ones in absolute values because they include the income effects of price changes. For the expenditure elasticities, a 1 percent increase in nonalcoholic beverage expenditures increased demand for milk by 0.614 percent and coffee/tea by 3.144 percent when all other demand factors were held constant. Our results do not imply that coffee/tea is a luxury good since the (conditional) expenditures elasticities are not equivalent to the unconditional income elasticities.

The (compensated) cross-price elasticities, E_{ij}^C, measure the percentage change in demand for beverage *i* with respect to a one percent price change in beverage *j* while holding utility level, other prices, and other demand factors (i.e., advertising, *Age*5, *Fafh*) constant. These compensated cross-price elasticities were positive for (net) substitutes and negative for (net) complements. Table 3 shows that compared with the own-price elasticities, the cross-price elasticities were not tiny and that in some rare cases they exceeded the own-price elasticities. For example, the own-price elasticity for coffee/tea was -0.083 and the cross-price elasticity of coffee/tea with respect to milk was -0.209. One reason for such a finding is that milk was found to be price-complement to coffee/tea demand and that milk was twice as expensive as coffee/tea (see Table 1). For the same percentage increase in coffee/tea and milk, coffee/tea consumers might be more responsive to the price increase in milk.

The top pair of substitutes and complements in terms of the absolute value of the cross-price elasticities is reported in Table 4. The top pair of price substitutes was milk and bottled water. For example, a 1 percent increase in the milk price increased demand for bottled water by 0.898 percent, while a 1 percent increase in the price of bottled water increased demand for milk by 0.433

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[3] The first-order autoregressive parameter was estimated to be -0.229 (statistically significant).

Table 3. Elasticities

	Compensated Price Elasticities					Expend. Elasticities	Uncompensated Price Elasticities
QUANTITY OF ...	E^C_{i1}	E^C_{i2}	E^C_{i3}	E^C_{i4}	E^C_{i5}	E_i	E^U_{ii}
Milk	-0.154**	-0.097**	-0.078**	0.433**	-0.105**	0.614**	-0.301**
Juice	-0.153**	-0.172**	0.549	-0.176**	-0.048**	0.656	-0.272
Soft drinks	-0.050**	0.224	-0.151**	-0.095**	0.071	0.997	-0.521**
Bottled water	0.898**	-0.232**	-0.305**	-0.498**	0.137**	0.029	-0.501**
Coffee/tea	-0.209**	-0.060**	0.220	0.131	-0.083**	3.144**	-0.462**
	Advertising Elasticities						
cont'd.	α_{i1}	α_{i2}	α_{i3}	α_{i4}	α_{i5}		
Milk	0.024**	0.049**	-0.156**	0.023**	0.115**		
Juice	0.010	-0.013	0.067	-0.075**	-0.098**		
Soft drinks	0.014	-0.053**	0.060**	-0.002	0.000		
Bottled water	-0.034	0.028	0.314**	0.040	-0.253**		
Coffee/tea	-0.071**	0.052	-0.258**	0.018	0.138**		

Table 4. Rank of Cross-Price and Advertising Elasticities

	PRICE SUBSTITUTES			PRICE COMPLEMENTS		
Rank	Quantity of	Price of	Elasticities	Quantity of	Price of	Elasticities
1	Bottled water	Milk	0.898	Bottled water	Soft drinks	-0.305
	Milk	Bottled water	0.433	Soft drinks	Bottled water	-0.095
	ADVERTISING SUBSTITUTES			ADVERTISING COMPLEMENTS		
Rank	Quantity of	Advertising of	Elasticities	Quantity of	Advertising of	Elasticities
1	Coffee/tea	Soft drinks	-0.258	Bottled water	Soft drinks	0.314
2	Bottled water	Coffee/tea	-0.253	Milk	Coffee/tea	0.115
3	Milk	Soft drinks	-0.156	Milk	Juice	0.049

percent (holding other demand factors constant). On the other hand, the top pair of price complements was bottled water and soft drinks. The demand elasticity for bottled water with respect to the price of soft drinks was -0.305 and -0.095 when reversed. While the complementary relation between milk and coffee/tea and between milk and juice is intuitive, such relation between the other four pairs—milk and soft drinks, bottled water and soft drinks, bottled water and juice, and coffee/tea and juice—is not. The complementary relation between fluid milk and juice is consistent with the findings of Ward and Dixon (1989) and Yen et al. (2004). Ward and Dixon (1989) found weak complementarity between orange juice and fluid milk, with an estimated elasticity of fluid milk consumption with respect to orange-juice price being -0.046. Yen et al. (2004) found that whole milk is a net complement to juice, while reduced-fat milk is not. An example of the complementary nature of milk and juice is that many people drink juice with their cereal and milk at breakfast.

Conditional Advertising Elasticities

For the own-advertising effects, we found that advertising had a positive and statistically significant impact on demand for milk, soft drinks, and coffee/tea. Advertising for juice and bottled water did not have a statistically significant own effect. Table 3 shows that the own-advertising elasticities were 0.024 for milk, 0.060 for soft drinks, and 0.138 for coffee/tea. For example, per capita demand and real advertising expenditures for milk were 21 gallons and $90 million, respectively, in 2005. Our finding suggests that a 1 percent increase in real milk advertising would increase per capita milk demand by 0.024 percent (holding all other demand factors constant). That is, an increase of $0.9 million in real milk advertising in 2005 would increase per capita demand for milk by 0.005 pounds.[4] Our estimated elasticity of 0.024 and Kinnucan et al.'s (2001) system estimate of 0.003 for milk's own-advertising elasticity are smaller than Kaiser's (2000, 2006) single-equation estimates of 0.051 for 1984–1999 and 0.056 for 1995–2005. This finding underscores the importance of taking spillover effects into account when measuring returns to advertising. In contrast, the own-advertising elasticities that Kinnucan et al. (2001) found to be statistically significant were 0.136 for juice and -0.100 for soft drinks. Our results suggest that coffee/tea advertising was the most successful in enhancing demand, followed by advertising of soft drinks and milk.

Eleven of the twenty cases demonstrated statistically significant spillover effects. Table 3 reveals that soft-drink and coffee/tea advertising exerted the largest influence within the group. For example, the demand elasticity of bottled water with respect to coffee/tea advertising was -0.253, indicating that a 1 percent increase in coffee/tea advertising could result in a 0.253 percent decrease in demand for bottled water, *ceteris paribus*. The top three pairs of advertising substitutes and complements, according to whether α_{ij} was less or greater than zero, are listed and ranked in Table 4. From Table 4, we conclude that coffee/tea advertising had a large, negative impact on demand for bottled water, as did soft-drink advertising on demand for coffee/tea and milk. On the other hand, soft-drink advertising was found to be a complement to demand for bottled water, as was coffee/tea and juice advertising to milk demand. The preceding advertising substitute and complement effects were all larger than the own-advertising elasticities for milk, and some were larger than the own-advertising elasticity for coffee/tea, which was 0.138. One reason that soft-drink advertising had a positive and large spillover effect on bottled-water demand is that a number of bottled-water brands belong to soft-drink companies. For example, the two biggest players in the soft-drink market, Coca-Cola Co. and Pepsi Co., own a number of major brands of water. Coca-Cola owns Dasani and Glaceau. Pepsi owns Aquafina, Propel, and SoBe. The positive spillover happens if advertising its cola enhances the image of Pepsi Co. and subsequently enhances the demand for other products under the same company such as Aquafina water.

We multiplied the elasticities obtained from Tables 2 and 3 by the percentage changes in the corresponding variables for the period 1974–2005 to demonstrate how changes in prices, advertising, expenditures, and demographics explained the changes in demand for the five beverages. Results are in Table 5. Take milk as an example. Actual milk demand decreased by 29 percent during this period, as indicated in the last row of Table 5. The most important factor that affected milk demand was *Fafh* (-52 percent), followed by the sum of price effects (-47 percent), expenditures (22 percent), sum of advertising effects (7 percent), and *Age*5 (-3 percent).[5] During this period, demand for bottled water increased nineteenfold. Of that increase, 153 percent was due to a large increase in the price of milk, 108 percent was due to the increase in the proportion of food expenditures that went to food consumed away from home, 16 percent was due to a large decrease in

[4] An anonymous reviewer of this journal article suggested that it would be interesting to calculate marginal rate of return of own advertising. Holding price constant, the marginal rate of return of milk advertising can be expressed as $p_1 \partial q_1 / \partial A_1 \times \text{Population} = p_1 \alpha_{11} q_1 \times \text{Population} / A_1$. Using the means in Table 1, the marginal rates of return of advertising to milk, soft-drink, and coffee/tea advertisers were 5.91, 2.61, and 4.52, respectively, which were all greater than one. Note that such returns do not take supply response into consideration.

[5] The *Fafh* effect on milk demand was calculated as the product of the percentage change in *Fafh* and the demand elasticity of milk with respect to *Fafh* (42.22% × (-1.234) = -52.09%). Other calculations followed similar procedures.

Table 5. Effects of Prices, Advertising, Expenditures, and Demographics on U.S. Nonalcoholic Beverage Demand, 1974–2005

		Milk		Juice		Soft Drinks		Bottled Water		Coffee/Tea	
Variable	Percent Change	Elasticity	Effect %	Elasticity	Effect %	Elasticity	Effect %	Elasticity	Effect %	Elasticity	Effect %
PRICES											
Milk	170.32	-0.154	-26.23	-0.153	-26.06	-0.050	-8.52	0.898	152.95	-0.209	-35.60
Juice	241.50	-0.097	-23.43	-0.172	-41.54	0.224	54.10	-0.232	-56.03	-0.060	-14.49
Soft drinks	152.57	-0.078	-11.90	0.549	83.76	-0.151	-23.04	-0.305	-46.54	0.220	33.57
Bottled water	90.37	0.433	39.13	-0.176	-15.91	-0.095	-8.59	-0.498	-45.01	0.131	11.84
Coffee/tea	234.98	-0.105	-24.67	-0.048	-11.28	0.071	16.68	0.137	32.19	-0.083	-19.50
Price effect sum			-47.10		-11.02		30.64		37.57		-24.19
ADVERTISING											
Milk	10.75	0.024	0.26	0.010	0.11	0.014	0.15	-0.034	-0.37	-0.071	-0.76
Juice	265.07	0.049	12.99	-0.013	-3.45	-0.053	-14.05	0.028	7.42	0.052	13.78
Soft drinks	30.40	-0.156	-4.74	0.067	2.04	0.060	1.82	0.314	9.55	-0.258	-7.84
Bottled water	257.02	0.023	5.91	-0.075	-19.28	-0.002	-0.51	0.040	10.28	0.018	4.63
Coffee/tea	-63.69	0.115	-7.32	-0.098	6.24	0.000	0.00	-0.253	16.11	0.138	-8.79
Advertising effect sum			7.09		-14.34		-12.59		43.00		1.01
EXPENDITURES	35.85	0.614	22.01	0.656	23.52	0.997	35.74	0.029	1.04	3.144	112.71
DEMOGRAPHICS											
Age5	-11.15	0.296	-3.30	-0.849	9.46	0.334	-3.72	-0.337	3.76	-0.216	2.40
Fafh	42.22	-1.234	-52.09	0.164	6.94	0.863	36.45	2.550	107.66	-2.861	-120.78
Demographic effect sum			-55.39		16.41		32.73		111.42		-118.38
Sum (of prices, advertising, expenditures, and demographic effects)			-73.38		14.57		86.53		193.03		-28.84
Actual consumption change			-28.79		41.05		86.67		1925.65		-20.86

Note: Effect = Percent change × elasticity.

advertising expenditures for coffee/tea, and 10 percent was due to an increase of soft-drink advertising, according to our model results. Note that although bottled-water advertising was not found to have any impact on its own demand, the decrease in expenditures for coffee/tea advertising and increase in advertising expenditures for soft drinks helped explain bottled water's success since bottled-water demand was found to be positively affected by soft-drink advertising and negatively affected by coffee/tea advertising. Overall, the *Fafh* effect exerted very large influence on the individual beverage demand. Our results affirm the existence of spillover effects and highlight their importance.

Comparison with Rotterdam Estimates and Other Studies

We also applied the same data to a Rotterdam model, replicating Kinnucan et al.'s (2001) study using an updated dataset. Such estimation also provides comparable estimates with our AIDS estimates, given the usual caveats regarding the linear AIDS model (e.g., Alston, Chalfant, and Piggott 2001, Moschini 1995, Buse 1994). The Rotterdam model shares the same structural form as equation (1) and is identical to the individual beverage demand specification in Kinnucan et al. (2001). In Table 6 we compared our compensated and uncompensated own-price, own-advertising, and expenditure elasticities with results from the Rotterdam model (denoted as "our Rotterdam" henceforth) and the two studies in the literature that modeled nonalcoholic beverages in a system-wide framework.

The overall implication of Table 6 is that the own-price effects (on beverage demand) remained more robust, consistent, and important across specifications than did the own-advertising effects. Specifically, for compensated elasticities, all beverages in the four specifications had negative and statistically significant own-price elasticities with the exception of bottled water in our Rotterdam estimates. The AIDS model yielded a compensated own-price elasticity of -0.498 for bottled water, while our Rotterdam model had a counterpart of 0.044, which was statistically insignificant. The two Rotterdam estimates of compensated elasticities compared favorably, e.g., -0.260 for coffee/tea in our Rotterdam model and -0.249 by Kinnucan et al. (2001). The differences between the two Rotterdam models are primarily due to our inclusion of bottled water and the fact that we employed data that covered a longer span of time. For milk and soft drinks, the AIDS model yielded comparable own-price elasticities with those obtained by the two Rotterdam models (-0.154 versus -0.102 and -0.169 for milk, -0.151 versus -0.164 and -0.137 for soft drinks); for juice and coffee/tea, the AIDS model tended to yield smaller price elasticities in absolute value, e.g., -0.172 versus -0.458 and -0.361 for juice. For uncompensated elasticities, the only two insignificant ones were juice in the AIDS model (-0.272) and bottled water in our Rotterdam model (0.051). The generally larger own-price elasticities (absolute values) in Yen et al. (2004) can be explained in part by their use of cross-sectional survey data. The consumption data generally had much more variation in the cross-sectional dimension than in the time-series dimension, resulting in larger elasticity estimates for studies using the cross-sectional data. All four specifications found that soft drinks and coffee/tea were more price-elastic (uncompensated) than was milk, and that coffee/tea was the most expenditure-elastic beverage within the group.

Compared with the price elasticities, Table 6 shows that the advertising elasticities tended to be more sensitive to model specification or sample updating. Similar findings were reported by Tomek and Kaiser (1999) for milk promotion effects, and by Kinnucan et al. (1997) and Coulibaly and Brorsen (1999) for beef promotion effects. In our AIDS model, the own-advertising effects for milk, soft drinks, and coffee/tea were statistically significant. All were positive. While all the own-advertising elasticities were positive in our Rotterdam model, none of them were significant. Such a finding is consistent with Zheng, Kinnucan, and Kaiser's (2008) study, where advertising was found to have a positive and significant elasticity on demand for milk, soft drinks and bottled water combined, and coffee/tea in a linear AIDS model, but not in a Rotterdam model. With shorter and older data applied to a Rotterdam model, Kinnucan et al. (2001) found that the own-advertising effect for soft drinks was negative and significant, a seemingly counterintuitive result. Kinnucan et al. (2001) also found that juice advertising had a large, positive impact on demand (an elasticity of 0.136). Yen et al. (2004) did not include advertising as an explanatory

Table 6. Comparison of Price, Advertising, and Expenditure Elasticities with Other Studies

					Own Elasticities			
	Model	Data	Conditional Demand	Products	Compensated Price	Uncompensated Price	Advertising	Expend. Elasticities
This study	AIDS model	Annual time series for 1974–2005	Yes	Milk	-0.154**	-0.301**	0.024**	0.614**
				Juice	-0.172**	-0.272	-0.013	0.656
				Soft drinks	-0.151**	-0.521**	0.060**	0.997
				Bottled water	-0.498**	-0.501**	0.040	0.029
				Coffee/tea	-0.083**	-0.462**	0.138**	3.144**
This study	Rotterdam model	Annual time series for 1974–2005	Yes	Milk	-0.102**	-0.161**	0.0001	0.243**
				Juice	-0.458**	-0.898**	0.016	2.891**
				Soft drinks	-0.164**	-0.306**	0.011	0.381**
				Bottled water	0.044	0.051	0.003	-0.062
				Coffee/tea	-0.260**	-0.628**	0.067	3.049**
Kinnucan et al. (2001)	Rotterdam model	Annual time series for 1970–1994	Yes	Milk	-0.169**	-0.283**	0.003	0.406**
				Juice	-0.361**	-0.471*	0.136**	0.698
				Soft drinks	-0.137**	-0.675**	-0.100**	1.238**
				Bottled water	NA	NA	NA	NA
				Coffee/tea	-0.249**	-0.487**	0.002	1.876**
Yen et al. (2004)	Translog demand system	National Food Stamp Program Survey, 1996–1997, 908 observations	Yes	Whole milk	-0.590**	-0.690**	NA	0.800**
				Juice	-0.350**	-0.520**	NA	0.900**
				Soft drinks	-0.520**	-0.800**	NA	1.010**
				Bottled water	NA	NA	NA	NA
				Coffee/tea	-0.470**	-0.890**	NA	1.130**

Notes: NA denotes that the variable was not included.

variable. Overall, although the AIDS model yields the most appealing results—e.g., significant own-price elasticity for bottled water, positive and significant advertising elasticity for milk, soft drinks, and coffee/tea, and high R^2's, etc.—decision makers should bear in mind the fact that advertising effects may not be invariant to specifications when interpreting the econometric estimates of the AIDS model.

Conclusions

This study is a first effort at modeling nonalcoholic beverage demand in a systemwide framework that includes bottled water. A five-equation AIDS model that includes advertising expenditures as explanatory variables reveals that bottled water is the most price-elastic category within the market for U.S. nonalcoholic beverages, which are all price-inelastic to varying degrees. Advertising positively affects demand for milk, soft drinks, and coffee/tea, but not for juice or bottled water. Interestingly, we found statistically significant cross-product advertising effects in over one-half of the cases considered. Effects of advertising substitutes and complements exist and can be substantial compared to own-advertising elasticities. Specifically, milk advertising is good for milk but bad for coffee/tea; juice advertising is good for milk but bad for soft drinks; soft-drink advertising is good for soft drinks and bottled water but bad for milk and coffee/tea; bottled water is good for milk but bad for juice; and coffee/tea advertising is good for coffee/tea and milk but bad for juice and bottled water. Overall, soft-drink and coffee/tea advertising exert the greatest influence within the beverage group.

Our findings have two implications for milk advertising. One is that more milk marketing efforts need to be made for away-from-home consumption. Indeed, dairy farmer marketing associations have started to do so recently. We found that as consumers consume more food away from home they drink less milk, which could be mainly due to the limited availability of conveniently packaged or flavored milk at restaurants and schools. Since 2005, dairy farmers have invested about $3 million a year in the "New Look of School Milk" program, which promotes serving a variety of flavored milk in single-serve plastic packages on the school meal line.

The second is that generic milk advertising has a distributional impact. We found that generic milk advertising increased milk demand at the expense of coffee/tea. Such a phenomenon was termed a "beggar-thy-neighbor" effect by Alston, Freebairn, and James (2001). This result raises a policy question about whether the government, in mandating economic studies of the direct impacts of checkoff programs, should also mandate looking at the distributional impact on related sectors.

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