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Impacts of Promotional Tactics in a Conditional Demand System for Beverages

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This study examined the impacts of four promotional tactics—features, displays, features and display together, and temporary price reductions—in context of a conditional demand system for 12 beverages. The Rotterdam model with promotion effects specified through the Tintner-Ichimura-Basmann relationship was used in the empirical study. The estimated conditional-demand equations exhibited relatively strong own- and cross-promotional effects, indicating a relatively high level of competition for market share among the beverages studied.

Key Words: advertising, demand, promotion, Rotterdam model

Various promotional tactics are used by food retailers to increase sales and revenues, including features (F), displays (D), features and displays together (F & D) and temporary price reductions (TPR). Features include best-food-day ads in newspapers, store flyers, circulars, and similar materials. Displays are exhibits of actual products in secondary store locations, cut cases placed next to regular shelf locations, and the same in primary locations when special effort is made in presenting the product. Displays give the product of interest more visibility. TPRs not only impact demand through price but also possibly influence consumer perceptions and preferences.

In this paper, a study of the impacts of these promotional tactics on beverage sales in grocery stores is discussed. The impacts on 12 different beverage categories are examined using a demand-system approach. A promotion aimed at a specific product might have a significant positive (own) impact on the sales of the product in question, but the gains might come at the expense of reduced sales of competitive products (cross impacts). Own- and cross-advertising/promotional impacts are inherent outcomes of the consumer budgeting process. Consumers have a limited amount of money to spend, and increased spending on one good must be offset by reduced spending on other goods. From this viewpoint, ignoring cross-promotional efforts when estimating own-promotional impacts could result in biased results. In this study, own- and cross-beverage-promotional impacts are examined in the context of a conditional Rotterdam demand system.

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Rotterdam Model

The Rotterdam model (Theil, 1971, 1975, 1976, 1980a, 1980b) specified in this study is a system of 12 differential beverage-demand equations. The specification of the promotional impacts is based on Barten's (1977) fundamental matrix equation of consumer demand and follows the approach used in modeling advertising effects by Theil (1980a), Duffy (1987, 1989), and Brown and Lee (1997, 2002), among others.

The Rotterdam model and the specification of promotional effects are directly related to the utility maximization problem confronting consumers—how to allocate income over available goods. The solution is the affordable bundle of goods that yields the greatest utility. In this problem, promotional variables are directly incorporated in the utility function as indicators of consumer preferences. The (unconditional) problem can be written as the maximization of $u = u(\mathbf{q}, \mathbf{z})$ subject to $\mathbf{p}'\mathbf{q} = x$, where u is utility; $\mathbf{p}' = (p_1, \ldots, p_n)$ and $\mathbf{q}' = (q_1, \ldots, q_n)$ are price and quantity vectors with p_i and q_i being the price and quantity of good i, respectively; $\mathbf{z}$ is a vector of promotional variables; and x is total expenditures or income. The first order conditions for this problem are $\partial u/\partial \mathbf{q} = \lambda \mathbf{p}$ and $\mathbf{p}'\mathbf{q} = x$, where λ is the Lagrange multiplier, which is equal to $\partial u/\partial x$, or the marginal utility of income. The solution to the first order conditions is the set of demand equations $\mathbf{q} = \mathrm{q}(\mathbf{p}, x, \mathbf{z})$ and the Lagrange multiplier equation $\lambda = \lambda(\mathbf{p}, x, \mathbf{z})$. The Rotterdam demand model is an approximation of this set of demand equations.

The i^{th} first order condition indicates that the marginal utility of good i ($\partial u/\partial q_i$) equals the price of good i (p_i) times the marginal utility of income (λ), or, at the margin, the amount of utility given up (λp_i) equals the amount of utility gained ($\partial u/\partial q_i$), in exchanging money for good i. Note that for the present specification of utility, the marginal utilities of goods depend on quantities and promotional levels ($\mathbf{q}$ and $\mathbf{z}$), given that utility depends on these factors; additionally, as mentioned above, λ depends on the promotional levels as well as prices and income. Thus, changes in the promotional variables result in changes in the marginal utilities of goods and income, and corresponding changes in demand levels occur. These relationships underlie this study's specification of promotional effects in the Rotterdam demand equations.

Assuming separability, we focused on the conditional demands for the subset of 12 beverages mentioned above. Following Theil (1976, 1980b), the conditional Rotterdam (differential) demand equation for beverage i can be written as

$$(1) \qquad w_i \mathrm{d}(\log q_i) = \theta_i \mathrm{d}(\log Q) + \textstyle\sum_j \pi_{ij}(\mathrm{d}(\log p_j) - \gamma_1 \mathrm{d}z_{1j} - \gamma_2 \mathrm{d}z_{2j} - \gamma_3 \mathrm{d}z_{3j} - \gamma_4 \mathrm{d}z_{4j}) + \beta_i, \qquad i = 1, \ldots, 12,$$

where now subscript i stands for a beverage; p_i and q_i are the price and quantity of beverage i, respectively; $w_i = p_i q_i / x$ or the budget share for beverage i, with $x = \sum_i p_i q_i$ or total expenditures on the 12 beverages or conditional income (referred to as income, for short); z_{1j}, z_{2j}, z_{3j}, and z_{4j} are the promotional tactic levels for features, displays, features and displays, and TPRs, respectively, for beverage *j*; $\theta_i = p_i(\partial q_i/\partial x)$ is the marginal propensity to consume (MPC) for beverage *i*; $d(\log Q) = \sum_i w_i d(\log q_i)$ is the Divisia volume index or change in real income;[1] $\pi_{ij} = (p_i p_j/x) k_{ij}$ is the Slutsky coefficient, with $k_{ij} = (\partial q_i/\partial p_j + q_j \partial q_i/\partial x)$ being the $(i, j)^{th}$ substitution effect; γ_k ($k = 1, \ldots, 4$) are promotional coefficients; and β_i is a constant to account for trends in sales of beverage *i*.

The level of a promotional tactic is measured by the percentage of all commodity volume (ACV) where that tactic is used (e.g., a z_{1j} value of 30 means that beverage *j* is featured in 30% of the stores sampled, weighted by store dollar sales on all retail items sold). The coefficient γ_k indicates the impact of promotional tactic *k* on the marginal utility of beverage *j*:

$$\gamma_k = \partial \log(\partial u/\partial q_j)/\partial z_{kj}, \qquad k = 1, \ldots, 4; j = 1, \ldots, 12. \tag{2}$$

A unit change in z_{kj} results in a γ_k percentage change in the marginal utility of beverage *j*. The coefficient γ_k is expected to be positive (i.e., an increase in tactic *k* for beverage *j* is expected to increase the marginal utility for beverage *j*). Given that tactic *k* is essentially the same across the 12 beverages except for having a beverage-specific emphasis, and given that the beverages are similar in their influence on utility,[2] γ_k is assumed to be the same across beverages. In addition to the impact of tactic *k* in promoting beverage *j* on that beverage's marginal utility, impacts on the marginal utilities of the other beverages might or might not occur. Assuming other beverages are subject to some generic or neutral impact on their marginal utilities as a result of the promotion, or alternatively no impacts on the other product marginal utilities occur, equation (1) directly follows (Brown and Lee, 2002). This specification is based on Theil's (1980b) treatment of advertising in the Rotterdam model, a parsimonious approach with respect to the advertising coefficients to be estimated. Depending on the richness of the data analyzed, the number of coefficients in a demand system might be larger than can be reliably estimated, and restrictions of some type might be considered to make the problem tractable. With the number of promotional effects growing by the square of the number goods in the system, there are 576 promotional impacts in our demand system (12 equations times 12 beverage-specific-promotional levels per tactic times four tactics), although the adding-up property reduces this number to 528 independent effects (inclusion of lagged promotional variables and corresponding coefficients increase this number, as considered below). Given the limited data available for this study, as subsequently discussed, estimation of such a large number of impacts independently is problematic. The specification of the promotional impacts in equation (1) through the Slutsky coefficients and the restrictions on the marginal utilities underlying

[1] The Divisia volume index is a close approximation of $d(\log x) - \sum w_i d(\log p_i)$, as shown by Theil (1971); $d(\log Q)$ is used instead of $d(\log x) - \sum w_i d(\log p_i)$ to insure adding-up.

[2] The beverages can be viewed similarly as uniform substitutes with respect to the impacts of promotion levels on marginal utilities (Theil, 1980b).

Theil's parameterization allow the promotional coefficients to be reduced to a manageable level.

The beverage promotional impacts specified in equation (1) are for current tactic levels. Promotions might, however, also have lagged impacts on demands, and, along with the current tactic levels, various lags of the tactic variables were considered in the empirical analysis. The specification of the lagged variables follows those for the current tactics, except for the magnitudes of the coefficients on the lagged variables. With one-period-lagged variables, for instance, the price term in equation (1) becomes $(d(\log p_{jt}) - \gamma_1 dz_{1jt} - \gamma_2 dz_{2jt} - \gamma_3 dz_{3jt} - \gamma_4 dz_{4jt} - \gamma_{11} dz_{1jt-1} - \gamma_{21} dz_{2jt-1} - \gamma_{31} dz_{3jt-1} - \gamma_{41} dz_{4jt-1})$, where t indicates time and the lag coefficients are γ_{11}, γ_{21}, γ_{31}, and γ_{41}.

Also, note that the impact of a TPR for beverage j involves price effects $(d(\log p_j) < 0)$ and the promotional effect γ_4. Our focus is on the promotional effects, with the price effects captured by the price variables of the model.

Modeling the promotional impacts on demand through the price effects or Slutsky coefficients as in equation (1) directly follows from the utility maximization problem and fundamental matrix equation of consumer demand. The impact on the demand for beverage i of tactic k used to promote beverage j is $-\pi_{ij}\gamma_k dz_{kj}$, based on the Tintner-Ichimura-Basmann relationship embedded in the fundamental matrix equation (Basmann, 1956; Brown and Lee, 1997, 2002; Tintner, 1952; Ichimura, 1950–51). This result also allows us to view the term $(d(\log p_j) - \gamma_1 dz_{1j} - \gamma_2 dz_{2j} - \gamma_3 dz_{3j} - \gamma_4 dz_{4j})$ in equation (1) as a perceived price that is impacted by the promotional variables; with γ_k being positive, an increase in tactic k for beverage j lowers the perceived price for this beverage. Also, note that variation in both the price and promotional variables contribute to the estimation of the Slutsky coefficients, a feature that might be interest in obtaining estimates of these coefficients when the data variability is limited.

The general restrictions on demand, imposed as part of our maintained hypothesis, are

(3) adding up: $\sum_i \theta_i = 1, \qquad \sum_i \pi_{ij} = 0, \qquad \sum_i \beta_i = 0,$

(4) homogeneity: $\sum_j \pi_{ij} = 0;$

(5) symmetry: $\pi_{ij} = \pi_{ji}.$

In general, the only restriction on the coefficients related to some promotion is that they add up (Barten, 1977; Brown and Lee, 2002); letting α_{ijk} be the impact of promotion k for product j in equation (1), this restriction is $\sum_i \alpha_{ijk} = 0$. For demand specification (1), this property is satisfied given $\alpha_{ijk} = -\pi_{ij}\gamma_k$ and the adding-up restrictions on the Slutsky coefficients (3). In general, there is no requirement that the promotion coefficients α_{ijk} in a single equation obey an advertising homogeneity property; that is, it is not necessary that $\sum_j \alpha_{ijk} = 0$. For Theil's (1980b) promotional specification used in this study, homogeneity of advertising does, however, hold based on the restrictions on the Slutsky coefficients (4).

Application

Conditional demands for beverages were studied using Nielsen data based on retail scanner sales for grocery stores, drug stores, and mass merchandisers, along with an estimate of Wal-Mart sales based on a consumer panel.[3] Twelve beverages were included in the model: (a) 100% orange juice, (b) 100% grapefruit juice, (c) 100% apple juice, (d) 100% grape juice, (e) remaining 100% juice, (f) vegetable juice, (g) less-than-100% juice drinks, (h) carbonated water, (i) water, (j) regular and diet soda, (k) liquid tea or tea for short, and (l) milk and shakes.

The data are weekly, from week ending June 28, 2003 through week ending June 3, 2006 (154 weekly observations). The raw data were comprised of gallon and dollar sales. In our application, quantity demanded was measured by per capita gallon sales, obtained by dividing raw gallon sales by the U.S. population; prices were obtained by dividing dollar sales by gallon sales. Sample mean per capita gallon sales, prices, budget shares and promotional tactic levels are shown in table 1.

The infinitely small changes in the logarithms of quantities and prices and in promotional variables in the differential model were measured by discrete differences (Theil, 1975, 1976). To account for seasonality, the variables were 52nd differenced (for the 52 weeks in a year) (i.e., $\mathrm{d}(\log q_{it}) = \log q_{it} - \log q_{it-52}$, $\mathrm{d}(\log p_{it}) = \log p_{it} - \log p_{it-52}$, and $\mathrm{d}z_{kt} = z_{kt} - z_{kt-52}$) (Duffy, 1987; Brown and Lee, 1997, 2000). Average budget share values underlying the differencing were used in constructing the model variables; that is, $w_{i,t}$ was replaced by $(w_{i,t} + w_{i,t-1})/2$.

The demand specifications studied are conditional on expenditure or income allocated to the 12 beverage categories. Income allocated to the beverage group was measured by the conditional Divisia volume index for this group, which was treated as independent of the error term added to each beverage-demand equation for estimation, based on the theory of rational random behavior (Theil, 1980a; Brown, Behr, and Lee, 1994). As the data added up by construction (i.e., the left-hand-side variables in the Rotterdam model sum over *i* to the conditional Divisia volume index), the error covariance matrix was singular, and an arbitrary equation was excluded (the model estimates are invariant to the equation deleted, as shown by Barten (1969)). The parameters of the excluded equation can be obtained from the adding-up conditions or by re-estimating the model after omitting a different equation. The equation error terms were assumed to be contemporaneously correlated, and the full information maximum likelihood procedure (TSP) was used to estimate the system of equations.

The conditional-demand estimates of model (1) are shown in table 2. The coefficients on current features, displays, and displays and features together were

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[3] Data are for U.S. grocery stores doing $2 million and greater annual sales, Wal-Mart stores excluding Sam's Clubs, mass-merchandisers, and drug stores doing $1 million and greater annual sales.

Table 1. Descriptive Statistics of Nielsen Beverage Sales in Grocery Stores

	Weekly Per Capita Sales (SSE Gallons)		Weekly Price ($/SSE Gallon)		Conditional Budget Share (%)	
Beverage	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Orange Juice	0.0428	0.0034	4.52	0.14	7.26	0.69
Grapefruit Juice	0.0015	0.0004	5.73	0.69	0.32	0.05
Apple Juice	0.0138	0.0022	3.62	0.19	1.87	0.29
Grape Juice	0.0039	0.0004	5.90	0.14	0.86	0.11
Rem. Fruit Juice	0.0119	0.0005	6.06	0.34	2.70	0.22
Vegetable Juice	0.0053	0.0006	6.78	0.39	1.36	0.14
Juice Drinks	0.0876	0.0122	3.70	0.15	12.09	0.90
Carbonated Water	0.0099	0.0009	2.79	0.14	1.03	0.06
Water	0.1341	0.0247	1.68	0.04	8.42	1.33
Soda	0.3499	0.0428	2.62	0.15	34.22	1.50
Tea	0.0157	0.0034	3.66	0.12	2.15	0.37
Milk	0.2173	0.0078	3.39	0.18	27.71	1.72

(extended . . . →)

[a] ACV stands for all commodity volume.

positive and significant at the $\alpha = .10$ level, indicating that these tactics positively impacted the marginal utilities underlying the beverage demands as intended (the impacts on quantities demanded are discussed subsequently). The TPR coefficient was positive but not significantly different from zero, suggesting that this tactic influences demand mainly through price. In addition to the current promotional tactic variables, the one-period-lagged levels of displays and features and displays together were found to have significant, positive impacts on the marginal utilities. The lagged coefficients for these variables were smaller than the corresponding current-period coefficients. The results indicate that, although these tactics are effective, their impacts decline relatively quickly over time. They immediately help move product but need to be maintained over time to continue to be effective. The lagged impacts of features alone and TPRs were not significantly different from zero at any reasonable level of α.

All own-Slutsky coefficients were negative and significant, indicating negatively sloped beverage demands as expected based on theory. The majority of the cross-Slutsky coefficients were positive and significant, indicating substitution relationships; of the remaining, most were insignificant, indicating neutral relations. All MPCs were positive and significant, indicating that these beverages are normal goods. Nine of the 12 constants were significant, indicating trends in consumption.

Table 1. Extended

Beverage	% of ACV[a] With Features		% of ACV With Displays		% of ACV With Features & Dis-plays		% of ACV With Temporary Price Reduc-tions	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Orange Juice	64.6	4.7	13.4	1.8	16.0	1.6	66.0	2.1
Grapefruit Juice	9.1	5.9	1.7	0.9	0.7	0.7	25.9	9.3
Apple Juice	37.4	5.8	33.0	3.7	18.5	4.2	65.4	3.8
Grape Juice	26.9	6.7	14.7	4.1	7.0	3.3	53.0	4.6
Rem. Fruit Juice	26.1	5.5	15.1	2.5	5.1	1.9	58.7	2.8
Vegetable Juice	17.6	5.8	9.9	3.3	3.3	2.0	54.1	3.3
Juice Drinks	73.2	9.3	72.5	11.0	40.9	12.1	91.0	1.7
Carbonated Water	14.8	4.2	15.6	4.1	3.7	1.9	43.1	3.6
Water	65.1	5.9	76.0	6.6	42.0	9.6	87.5	2.9
Soda	81.1	3.3	74.7	2.3	70.1	3.3	88.6	1.5
Tea	33.5	8.7	42.8	8.5	11.1	5.1	79.0	3.1
Milk	29.1	4.6	2.0	0.6	1.0	0.3	60.9	7.7

The constants for vegetable juice, juice drinks, and soda were not significant. The constants for orange juice, grapefruit juice, apple juice, grape juice, and milk were negative, indicating declines over time in the demands for these beverages, all else constant; remaining juice, carbonated water, water, and tea had positive constants, indicating increasing demands over time.

Conditional growth rates (β_i/w_i), income elasticities ($e_i = \theta_i/w_i$), compensated price elasticities ($e^*_{ij} = \pi_{ij}/w_i$), and uncompensated price elasticities ($e_{ij} = \pi_{ij}/w_i - w_j e_i$), estimated at the sample mean budget shares, are shown in table 3. The conditional compensated own-price elasticities (underlying the promotional impacts to be discussed) ranged from −0.1 for milk to −2.1 for grape juice; the compensated cross-price elasticities ranged from −0.5 (milk price on grapefruit-juice demand) to 2.0 (soda price on grape-juice demand). Conditional income elasticities ranged from 0.4 for milk to 1.6 for water.

The impacts (elasticities) of the promotional tactics are shown in tables 4 through 6. These impacts are estimated at mean budget share values as $d(\log q_{it}) = dq_{it}/q_{it} = -\pi_{ij}(\gamma_k z_{kjt} + \gamma_{k1} z_{kjt-1})/w_i$, with the lagged coefficients (γ_{k1}) for features and TPRs being zero. Various values of z_{kj} were considered. The impacts indicate the percentage change in demand for the promotional levels assumed. First, table 4 shows estimates of maximum tactic impacts by beverage, assuming that for beverage *i* the current and lagged values of z_{ki} (ACV) are 100, with all other beverage tactic values (z_{kj}) held at zero. Based on these results, features and displays together (displays alone) have the largest (second largest) impacts on demand, ranging from a 0.8% (0.5%)

Table 2. Maximum Likelihood Estimates of the Conditional Rotterdam Demand System for Beverages with Promotional Tactic Effects

			Slutsky Coefficient Estimate				
Beverage	Constant Estimate	MPC Estimate	Orange Juice	Grapefruit Juice	Apple Juice	Grape Juice	Rem. Fruit Juice
Orange Juice	−0.0038	0.0564	−0.0721	0.0011	0.0044	0.0036	0.0092
	(0.0004)[a]	(0.0074)	(0.0075)	(0.0006)	(0.0021)	(0.0018)	(0.0030)
Grapefruit Juice	−0.0003	0.0041	0.0011	−0.0051	−0.0002	−0.0012	0.0010
	(0.0000)	(0.0005)	(0.0006)	(0.0002)	(0.0003)	(0.0003)	(0.0004)
Apple Juice	−0.0006	0.0101	0.0044	−0.0002	−0.0262	0.0028	0.0041
	(0.0001)	(0.0021)	(0.0021)	(0.0003)	(0.0013)	(0.0008)	(0.0012)
Grape Juice	−0.0008	0.0116	0.0036	−0.0012	0.0028	−0.0180	−0.0024
	(0.0001)	(0.0015)	(0.0018)	(0.0003)	(0.0008)	(0.0013)	(0.0012)
Rem. Fruit Juice	0.0012	0.0223	0.0092	0.0010	0.0041	−0.0024	−0.0424
	(0.0002)	(0.0027)	(0.0030)	(0.0004)	(0.0012)	(0.0012)	(0.0024)
Vegetable Juice	0.0000	0.0120	0.0074	−0.0008	0.0030	−0.0012	−0.0022
	(0.0001)	(0.0015)	(0.0020)	(0.0003)	(0.0009)	(0.0010)	(0.0013)
Juice Drinks	−0.0007	0.1507	0.0164	0.0014	0.0009	0.0062	0.0075
	(0.0006)	(0.0104)	(0.0075)	(0.0007)	(0.0028)	(0.0024)	(0.0039)
Carbonated Water	0.0002	0.0130	−0.0027	−0.0002	−0.0002	−0.0020	0.0043
	(0.0001)	(0.0010)	(0.0013)	(0.0003)	(0.0007)	(0.0008)	(0.0009)
Water	0.0076	0.1302	0.0174	0.0015	0.0012	0.0005	0.0051
	(0.0008)	(0.0138)	(0.0077)	(0.0007)	(0.0027)	(0.0022)	(0.0037)
Soda	0.0013	0.4385	0.0071	0.0042	0.0039	0.0170	0.0168
	(0.0013)	(0.0240)	(0.0091)	(0.0006)	(0.0028)	(0.0020)	(0.0037)
Tea	0.0032	0.0273	0.0070	−0.0001	0.0036	−0.0030	0.0008
	(0.0003)	(0.0043)	(0.0036)	(0.0004)	(0.0014)	(0.0012)	(0.0019)
Milk	−0.0074	0.1239	0.0013	−0.0015	0.0027	−0.0022	−0.0019
	(0.0006)	(0.0163)	(0.0031)	(0.0002)	(0.0009)	(0.0006)	(0.0011)
Promo Coeff.	Features	Displays	Lag Disp.	F&D[b]	Lag F&D	TPRs[c]	
	0.0002	0.0005	0.0004	0.0009	0.0005	0.0002	
	(0.0001)	(0.0002)	(0.0002)	(0.0002)	(0.0001)	(0.0001)	

(extended . . . →)

[a] Standard errors in parentheses.
[b] Denotes the promotional tactic of features and displays together.
[c] Denotes the promotional tactic of temporary price reductions.

increase in milk demand to a 29.0% (19.8%) increase in grape-juice demand. The results suggest that the effectiveness of featuring alone might be limited, but when featuring accompanies displays the joint effect might be large. However, features, as well as the other tactics, might further impact demands through price changes, but disaggregated promotional versus non-promotional prices were not available to examine these possible impacts (the impacts of tactic price changes are embedded in the model's price effects with the price variables being weighted averages of the

Table 2. Extended

	Slutsky Coefficient Estimate						
Beverage	Vegetable Juice	Juice Drinks	Carbonated Water	Water	Soda	Tea	Milk
Orange Juice	0.0074 (0.0020)	0.0164 (0.0075)	−0.0027 (0.0013)	0.0174 (0.0077)	0.0071 (0.0091)	0.0070 (0.0036)	0.0013 (0.0031)
Grapefruit Juice	−0.0008 (0.0003)	0.0014 (0.0007)	−0.0002 (0.0003)	0.0015 (0.0007)	0.0042 (0.0006)	−0.0001 (0.0004)	−0.0015 (0.0002)
Apple Juice	0.0030 (0.0009)	0.0009 (0.0028)	−0.0002 (0.0007)	0.0012 (0.0027)	0.0039 (0.0028)	0.0036 (0.0014)	0.0027 (0.0009)
Grape Juice	−0.0012 (0.0010)	0.0062 (0.0024)	−0.0020 (0.0008)	0.0005 (0.0022)	0.0170 (0.0020)	−0.0030 (0.0012)	−0.0022 (0.0006)
Rem. Fruit Juice	−0.0022 (0.0013)	0.0075 (0.0039)	0.0043 (0.0009)	0.0051 (0.0037)	0.0168 (0.0037)	0.0008 (0.0019)	−0.0019 (0.0011)
Vegetable Juice	−0.0270 (0.0015)	0.0084 (0.0027)	0.0008 (0.0008)	−0.0002 (0.0024)	0.0158 (0.0021)	−0.0036 (0.0013)	−0.0004 (0.0007)
Juice Drinks	0.0084 (0.0027)	−0.1792 (0.0148)	−0.0006 (0.0017)	0.0439 (0.0104)	0.0905 (0.0131)	0.0119 (0.0048)	−0.0074 (0.0041)
Carbonated Water	0.0008 (0.0008)	−0.0006 (0.0017)	−0.0174 (0.0009)	0.0033 (0.0016)	0.0094 (0.0013)	0.0043 (0.0009)	0.0010 (0.0004)
Water	−0.0002 (0.0024)	0.0439 (0.0104)	0.0033 (0.0016)	−0.1417 (0.0149)	0.1074 (0.0154)	−0.0027 (0.0049)	−0.0356 (0.0054)
Soda	0.0158 (0.0021)	0.0905 (0.0131)	0.0094 (0.0013)	0.1074 (0.0154)	−0.3392 (0.0316)	0.0025 (0.0057)	0.0646 (0.0090)
Tea	−0.0036 (0.0013)	0.0119 (0.0048)	0.0043 (0.0009)	−0.0027 (0.0049)	0.0025 (0.0057)	−0.0154 (0.0032)	−0.0053 (0.0018)
Milk	−0.0004 (0.0007)	−0.0074 (0.0041)	0.0010 (0.0004)	−0.0356 (0.0054)	0.0646 (0.0090)	−0.0053 (0.0018)	−0.0153 (0.0071)

promotional and non-promotional prices). As noted above, TPRs positively impacted the marginal utilities, but the corresponding t-statistic (1.3) and the probability greater than the absolute value of this t-value (0.2) were relatively small and large, respectively. To the extent, however, that TPRs are exerting a positive effect on the marginal utilities, combining features, displays, and TPRs results in demand impacts that range from 0.8% (milk) to 32.6% (grape juice).[4]

Although the model describes average U.S. per capita beverage demands, the results provide an indication of the impacts in the average store. For example, at times the average store might promote just one beverage for a week or two, then discontinue this promotion and begin promoting another beverage, and so forth, avoiding the promotion of two or more beverages at the same time. The average consumer shopping at this store gets a promotion dose (z_{kj}) of 100 when the beverage

[4] At the Universal Product Code (UPC) level, the four tactics are defined as mutually exclusive. For the orange juice group, comprised of many individual products, however, combinations of tactics are possible.

Table 3. Conditional Beverage Demand Growth Rates, and Income Elasticities at Sample Mean Budget Shares

			Price (Compensated)											
Beverage	Growth Rate	Income	Orange Juice	Grapefruit Juice	Apple Juice	Grape Juice	Rem. Fruit Juice	Vegetable Juice	Juice Drinks	Carbonated Water	Water	Soda	Tea	Milk
Orange Juice	−0.052	0.776	−0.993	0.015	0.060	0.049	0.126	0.102	0.226	−0.037	0.239	0.098	0.096	0.018
Grapefruit Juice	−0.098	1.302	0.334	−1.616	−0.078	−0.372	0.322	−0.252	0.450	−0.058	0.457	1.320	−0.043	−0.464
Apple Juice	−0.032	0.535	0.233	−0.013	−1.394	0.147	0.220	0.159	0.049	−0.009	0.064	0.206	0.191	0.145
Grape Juice	−0.090	1.354	0.419	−0.139	0.324	−2.111	−0.281	−0.142	0.726	−0.236	0.056	1.988	−0.351	−0.256
Rem. Fruit Juice	0.045	0.830	0.341	0.038	0.154	−0.089	−1.574	−0.081	0.279	0.162	0.188	0.625	0.030	−0.072
Vegetable Juice	−0.003	0.889	0.550	−0.059	0.222	−0.090	−0.162	−2.005	0.625	0.057	−0.015	1.172	−0.268	−0.027
Juice Drinks	−0.006	1.251	0.136	0.012	0.008	0.052	0.062	0.070	−1.489	−0.005	0.364	0.752	0.099	−0.061
Carbonated Water	0.021	1.251	−0.257	−0.018	−0.016	−0.195	0.420	0.075	−0.062	−1.678	0.321	0.904	0.411	0.095
Water	0.091	1.559	0.208	0.017	0.014	0.006	0.061	−0.002	0.526	0.040	−1.697	1.287	−0.032	−0.427
Soda	0.004	1.283	0.021	0.012	0.011	0.050	0.049	0.046	0.265	0.027	0.314	−0.993	0.007	0.189
Tea	0.152	1.282	0.329	−0.006	0.168	−0.141	0.038	−0.170	0.561	0.200	−0.125	0.119	−0.722	−0.251
Milk	−0.026	0.444	0.005	−0.005	0.010	−0.008	−0.007	−0.001	−0.026	0.004	−0.128	0.231	−0.019	−0.055

(continued . . .)

Table 3. Continued

Beverage	Price (Uncompensated) Orange Juice	Grapefruit Juice	Apple Juice	Grape Juice	Rem. Fruit Juice	Vegetable Juice	Juice Drinks	Carbonated Water	Water	Soda	Tea	Milk
Orange Juice	−1.049	0.012	0.046	0.043	0.105	0.092	0.132	−0.045	0.174	−0.167	0.080	−0.199
Grapefruit Juice	0.240	−1.620	−0.103	−0.383	0.287	−0.270	0.293	−0.071	0.348	0.875	−0.070	−0.828
Apple Juice	0.194	−0.015	−1.404	0.143	0.206	0.152	−0.015	−0.014	0.020	0.023	0.179	−0.004
Grape Juice	0.321	−0.143	0.298	−2.122	−0.317	−0.160	0.563	−0.250	−0.057	1.526	−0.380	−0.634
Rem. Fruit Juice	0.281	0.035	0.138	−0.096	−1.597	−0.092	0.179	0.153	0.119	0.341	0.013	−0.304
Vegetable Juice	0.485	−0.062	0.206	−0.097	−0.186	−2.017	0.518	0.048	−0.089	0.868	−0.287	−0.275
Juice Drinks	0.045	0.008	−0.016	0.041	0.029	0.053	−1.639	−0.018	0.260	0.324	0.073	−0.411
Carbonated Water	−0.348	−0.022	−0.039	−0.205	0.386	0.058	−0.212	−1.691	0.217	0.476	0.384	−0.254
Water	0.095	0.012	−0.015	−0.008	0.019	−0.023	0.338	0.024	−1.828	0.754	−0.065	−0.862
Soda	−0.072	0.008	−0.013	0.039	0.015	0.029	0.110	0.014	0.207	−1.431	−0.020	−0.169
Tea	0.236	−0.010	0.144	−0.152	0.004	−0.187	0.406	0.186	−0.232	−0.319	−0.750	−0.609
Milk	−0.028	−0.007	0.001	−0.012	−0.019	−0.007	−0.080	−0.001	−0.165	0.080	−0.029	−0.179

is promoted and zero when it is not. For example, if a store's beverage focus for a week is on promoting orange juice only, using features, displays, and TPRs together, orange juice volume sales in that store and in that week are estimated to increase by 15.3%. Overall, table 4 illustrates that promoting one beverage alone might result in relatively large impacts on the demand for that beverage. What table 4 does not show are the negative cross-promotional impacts.

Table 4. Maximum Promotional Tactic Impacts[a]

Beverage	Features	Displays	F&D[b]	TPRs[c]	F&D &TPRs
	% Change in Quantity Demanded				
Orange Juice	2.0	9.3	13.6	1.7	15.3
Grapefruit Juice	3.3	15.1	22.2	2.8	25.0
Apple Juice	2.9	13.0	19.2	2.4	21.6
Grape Juice	4.3	19.8	29.0	3.6	32.6
Rem. Fruit Juice	3.2	14.7	21.6	2.7	24.3
Vegetable Juice	4.1	18.8	27.6	3.4	31.0
Juice Drinks	3.1	13.9	20.5	2.5	23.0
Carbonated Water	3.5	15.7	23.1	2.9	25.9
Water	3.5	15.9	23.3	2.9	26.2
Soda	2.0	9.3	13.6	1.7	15.3
Tea	1.5	6.8	9.9	1.2	11.2
Milk	0.1	0.5	0.8	0.1	0.8

[a] Assumes promotional tactic ACV (all commodity volume) is 100% for beverage; no promotions for competitive beverages.
[b] Denotes the promotional tactic of features and displays together.
[c] Denotes the promotional tactic of temporary price reductions.

Own- and cross-promotional impacts at sample mean tactic levels and budget shares are shown in table 5. The results indicate the percentage changes in beverage demands assuming that promotional tactics for all beverages change from zero to their sample mean values and show the competitive nature of the tactics across beverages. Both own- and (aggregate) cross-promotional impacts are provided (z_{ki} and z_{kj} [all $j \neq i$] on d(log q_{it}), respectively). For example, orange juice features increase the demand for orange juice by 1.3%, but other beverage features decrease orange juice demand by 1.1%, leaving the net increase at 0.2%. Although the own-promotional effects are all positive, the net increases across tactics for most of the beverages are negative due to relatively strong negative cross effects. Again, for example, when features, displays, and TPRs occur together, the orange-juice own impact of a 3.3% increase in demand is more than offset by negative cross impacts (−5.4% in aggregate), resulting in a net impact of −2.1%. These results do not imply that beverages with negative net impacts should stop promoting. On the contrary, doing so might result in much larger demand declines, assuming some competitive beverages continue promoting, negatively impacting the demands of those beverages

Table 5. Promotional Tactic Impacts at Sample Mean Budget Shares and Promotional Tactic Levels

	Features			Displays			Features & Displays			Temporary Price Reductions			Features & Displays and Temporary Price Reductions		
Beverage	Own	Cross	Sum	Own	Cross	Sum	Own	Cross	Sum	Own	Cross	Sum	Own	Cross	Sum
	% Change in Quantity Demanded														
Orange Juice	1.3	−1.1	0.2	1.2	−4.8	−3.5	2.2	−4.1	−1.9	1.1	−1.3	−0.2	3.3	−5.4	−2.1
Grapefruit Juice	0.3	−3.4	−3.1	0.3	−15.1	−14.8	0.1	−18.0	−17.9	0.7	−2.8	−2.1	0.9	−20.9	−20.0
Apple Juice	1.1	−1.3	−0.2	4.3	−4.0	0.3	3.5	−3.8	−0.3	1.6	−1.6	−0.1	5.1	−5.5	−0.4
Grape Juice	1.2	−4.6	−3.4	2.9	−18.4	−15.5	2.0	−24.3	−22.3	1.9	−3.7	−1.8	4.0	−28.0	−24.1
Rem. Fruit Juice	0.8	−2.2	−1.4	2.2	−8.6	−6.4	1.1	−9.8	−8.7	1.6	−2.2	−0.6	2.7	−12.0	−9.3
Vegetable Juice	0.7	−3.5	−2.7	1.9	−12.3	−10.5	0.9	−15.9	−15.0	1.9	−3.0	−1.1	2.8	−18.9	−16.1
Juice Drinks	2.2	−2.1	0.2	10.1	−8.6	1.5	8.4	−9.9	−1.6	2.3	−2.1	0.2	10.7	−12.0	−1.3
Carbonated Water	0.5	−2.0	−1.5	2.4	−9.9	−7.4	0.8	−10.4	−9.5	1.2	−2.4	−1.2	2.1	−12.8	−10.7
Water	2.3	−3.0	−0.7	12.1	−12.8	−0.7	9.8	−15.8	−6.0	2.5	−2.6	−0.1	12.3	−18.4	−6.1
Soda	1.7	−1.1	0.6	6.9	−4.4	2.6	9.6	−3.5	6.0	1.5	−1.3	0.2	11.1	−4.8	6.2
Tea	0.5	−1.2	−0.7	2.9	−4.6	−1.7	1.1	−4.6	−3.5	1.0	−1.1	−0.1	2.1	−5.7	−3.6
Milk	0.0	−0.2	−0.1	0.0	−0.5	−0.5	0.0	−1.3	−1.3	0.1	−0.1	0.0	0.1	−1.4	−1.4

that discontinue promoting. Promoting appears to be part of the cost of preserving market share.

Table 6. Total Beverage Promotional Tactic Impacts at Sample Mean Budget Shares and Promotional Tactic Levels

Beverage	Features & Displays and Temporary Price Reductions: Own	Cross	Sum	Share of Total Mean Gallons
	% Change in Quantity Demanded			
Orange Juice	3.3	−5.4	−2.1	4.8
Grapefruit Juice	0.9	−20.9	−20.0	0.2
Apple Juice	5.1	−5.5	−0.4	1.5
Grape Juice	4.0	−28.0	−24.1	0.4
Rem. Fruit Juice	2.7	−12.0	−9.3	1.3
Vegetable Juice	2.8	−18.9	−16.1	0.6
Juice Drinks	10.7	−12.0	−1.3	9.8
Carbonated Water	2.1	−12.8	−10.7	1.1
Water	12.3	−18.4	−6.1	15.0
Soda	11.1	−4.8	6.2	39.2
Tea	2.1	−5.7	−3.6	1.8
Milk	0.1	−1.4	−1.4	24.3
All Beverages[a]	7.6	−7.2	0.4	100.0

[a] Weighted average based on mean-gallon shares.

Given that many of the beverages have negative net promotional impacts, one might wonder what the net promotional impact on gallon sales of all 12 beverages in aggregate is. We examined this question for the combination of features and displays and TPRs (table 6). The aggregate net impact was calculated as a weighted sum of the individual beverage net impacts, with the weights being the beverage shares out of group gallon sales (aggregate gallons across the 12 beverages). The results indicate these promotions would slightly increase overall beverage gallon sales by 0.4%. Soda pop is the principle product supporting this result, being the lone beverage with a positive net impact (6.2%) and having a relatively large share (39.2%) of total beverage gallons.

The above aggregate results should not be surprising given the budget constraints faced by consumers. For the unconditional budgeting process, consumers have limited money to allocate across goods. Promotions might result in a reallocation of spending, but the total amount spent must remain unchanged. At the conditional budgeting level, the same result holds: beverage promotions reallocate a given amount of money spent on the product group. The demand responses at the conditional and unconditional levels, however, might not be equal. To determine unconditional impacts, knowledge of the demands for goods outside the beverage category is needed. The impacts of the beverage promotions on the aggregate amount of money allocated to the group of 12 beverages are required. Beverage promotions not only might result in reallocation of spending between beverages but also might attract consumer spending away from other non-beverage goods. Thus, although the conditional results of this study suggest a very competitive beverage category with winners and losers, the possibility that the unconditional responses might differ should be recognized. Data limitations precluded addressing this broader issue.

Concluding Comments

This study examined the impacts of four promotional tactics—features, displays, features and displays together, and TPRs—in the context of a conditional demand system for 12 beverages. Consumer demands were specified as functions of real income spent on the beverage group and prices and promotional levels of the 12 beverages. When consumer income is fixed, changes in promotional levels, as well as prices, result in a reallocation of expenditures. The consumer budgeting process suggests that not only own- but also cross-promotional effects might be important in understanding market behavior. The findings of this study supported this conjecture.

The Rotterdam model, with promotion effects specified through the Tintner-Ichimura-Basmann relationship, was used in the empirical analysis. With 12 goods and four promotional tactics, there were 576 (12×12×4) current-period own- and cross-promotional impacts plus another 288 (12×12×2) lagged impacts in this study. Given the data limitations faced, some structure on the promotional impacts was needed to estimate the large number of effects considered. The Tintner-Ichimura-Basmann relationship in combination with some reasonable assumptions made by Theil (1980b) provided a structure for this purpose. The promotional effects were related to the price effects, reducing the parameter space to a manageable level.
The estimated conditional-beverage-demand equations exhibited relatively strong own- promotional effects. Cross-promotional effects, however, tended to offset the own effects for most of the beverages. Soda pop had the largest net (own and cross) demand response to promotions, while grape juice had the smallest. Overall, the results suggest a relatively high level of competition for market share among the beverages studied. Caution, however, should be taken in interpreting these results. The unconditional demand responses might differ from the conditional responses estimated here to the extent that the promotional tactics result in a reallocation of spending from goods outside the beverage group to goods within the beverage group.

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