Demand Interrelationships of At-Home Nonalcoholic Beverage Consumption in the United States

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Abstract

In this study we modeled demand interrelationships of at-home nonalcoholic beverage consumption in the United States using a unique data set developed using Nielsen HomeScan panel data of household purchases of nonalcoholic beverages over the period January 1998 through December 2003. We used 72 monthly observations of expenditure shares, real prices and real per capita expenditures of 10 unique categories of nonalcoholic beverages in a full-blown AIDS model with an adjustment for seasonal (quarterly) variability in data.

Compared to similar studies done in the past, our study used a rich delineation of nonalcoholic beverage categories, and in particular introduced isotonics for the first time. Furthermore, our study provided more information about important sub categories of nonalcoholic beverages, such as, regular and diet soft drink partition to soft drink category, high-fat and low-fat partition to milk category, and fruit drinks and fruit juices partition in fruit beverages category. It also separated the effects of tea and coffee, unlike past studies in the literature where both tea and coffee were analyzed as a single category.

Estimated own-price elasticities were theoretically consistent sign-wise (negative sign) and majority of compensated cross-price elasticities revealed that most of (60%) of nonalcoholic beverages were net substitutes. We found that isotonics were the most price and expenditure elastic nonalcoholic beverage and it is followed by regular soft drinks. Furthermore, milk was found to be net complements with fruit drinks, fruit juices, water, and tea. Additionally, diet and regular soft drinks were also net complements. Fruit juice and fruit drinks were found to be net substitutes. Our study further showed that high-fat milk was a net substitute for low-fat milk.

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Background

There are so many different types of nonalcoholic beverages available today compared to say two decades ago. Support for this contention is evident with a visit to the nonalcoholic beverages isle of any grocery store. According to trends given from the Statistical Abstract of the Unites States (2006) and United States Department of Agriculture (USDA), Economic Research Service (ERS) (2009), the nonalcoholic beverage industry has changed dramatically over the past decade and a half. For example, there is a phenomenal growth in the bolted water consumption where the per capita consumption increased from 1.6 gallons per year in 1976 to 29 gallons per year in 2007.

On the other hand, per capita milk consumption as a whole decreased from 31.3 gallons per year in 1970 to 21 gallons per year in 2007. More specifically, whole milk consumption dropped dramatically from 25.5 gallons per person per year in 1970 to 6.4 gallons per person per year in 2007. Low fat and nonfat milk consumption showed a reserves trend where, per capita consumption in 1970 was 5.8 gallons, which increased up to 14.3 in 2007.

Consumption of carbonated soft drinks (sodas) increased from 33.6 gallons per person per year in 1980 to 53.8 gallons per person in 1998 and since then there is a steady decline toward 2007 (48.8 gallons per person per year in 2007). Coffee consumption was 33.3 gallons per person per year in 1970 and it was dropped to 24.5 gallons per person per year in 2007.

These trends may have occurred due to various reasons. Changes in consumer tastes and preferences and availability of a wide variety of new products in the market may be contributing factors of such trends. For example, in the 1970s, beverages were predominantly viewed as basic refreshments. However, functionality and health dimension of beverages have emerged currently, so that beverages are available for mood enhancement, hydration, nutrient fortification, etc. (Beverage Marketing Corporation (BMC), 2008). Finally, after changes in the dietary guidelines for Americans put forward by the USDA in 2000 and 2005, changes in the consumption of non-alcoholic beverages are evident (Dharmasena, Capps, and Clauson, 2009).

Several studies pertaining to nonalcoholic beverages have been conducted, but most of these have centered attention on specific items. A heavy concentration of these studies has been placed on milk consumption in the United States. Advertising often is a key focus in previous studies pertaining to milk (e.g. Kinnucan and Forker, 1986 and Kaiser and Roberte, 1996). Some studies also have considered demand interrelationships for several beverages. Examples include Xiao, Kinnucan, and Kaiser (1998) focusing attention on milk, juices, soft drinks, and coffee and tea combined; Heien and Wessels (1988) considering milk, soda, coffee and tea combined, fruit ades, and citrus juices; Richertson (1998) addressing hot drinks, milk, soft drinks, alcohol, and all other food; and Zheng and Kaiser (2008) centering attention on fluid milk, juice, soft drinks, bottled water, coffee and tea combined.

Some studies in the literature also have emphasized complementary and substitutability among nonalcoholic beverages through a formal demand systems approach. Again, only a few other beverage categories have been incorporated into these studies.

Thus, certain beverages may not have been included in the set of items. Kinnucan (1986), Gould *et.al.* (1990), Gould (1996), Kaiser and Reberte (1996), Ueda and Frechette (2002) all have conducted demand systems analyses focusing primarily on milk. Kinnucan et al, (2001) and Yen et al., (2004) again focused a limited set of nonalcoholic beverages including milk, tea and coffee in a demand systemwide framework. However, two studies in the literature cover a richer set of nonalcoholic beverages in a systemwide framework, notably Pittman (2004) and Zheng and Kaiser (2008). Pittman (2004) analyzed demand interrelationships using the 1999 ACNielsen Homescan Panel for a disaggregate set of nonalcoholic beverages. Zheng and Kaiser (2008) focused on fluid milk, juice, soft drinks, bottled water, and coffee and tea (combined) using annual time series data for the United States from 1974 through 2005 in estimating impacts of advertising on the demand for nonalcoholic beverages in the United States.

In our analysis, we develop and employ a unique time series data set based on ACNielsen Homsescan panels for household purchases of nonalcoholic beverages from 1998 through 2003. Using such data along with a rich delineation of nonalcoholic beverage categories (we employ 10 categories of nonalcoholic beverages), we estimate demand relationships for nonalcoholic beverages using a demand systems approach. This study generates important information not only for government policy makers but also for beverage manufacturers, marketers, advertisers/promoters and managers in grocery stores. Knowledge of own-price sensitivity, substitutability/complementarity among beverages, and responsiveness to advertising is very important to manufactures and promoters within the beverage industry.

Objectives

In this light, the specific objectives of this study are two fold; (1) using the unique time series data set, to investigate the demand for ten nonalcoholic beverage categories; and (2) to estimate own-price and cross-price elasticities of demand for these nonalcoholic beverages. The specific categories of nonalcoholic beverages considered in this analysis are: isotonics; regular soft drinks; diet (low calorie) soft drinks; high-fat milk (whole and 2% milk); low-fat milk (1% and skim milk); fruit drinks; fruit juices; bottled water; coffee; and tea. Consequently, our work centers attention on demand interrelationships for ten nonalcoholic beverages.

Organization

This paper is organized as follows. We initially discuss the trends in the nonalcoholic beverage market in the United States over the past three decades and we briefly review past studies done on nonalcoholic beverage market. Subsequently, we present a narrative on data and the methodology used to address the aforementioned objectives. Next, we provide a description of the demand systems approach we employ in this study. Further, we provide the empirical results of the estimated demand system model, followed by a comparison of our results with similar past studies. Finally, we make concluding remarks and provide some limitations on the basis of our work.

Methodology

In the following section, we discuss in detail, the data used in the study followed by the model and estimation issues.

Data Description

The source of the data for this analysis is the ACNielsen Homescan panel data for calendar years 1998 through 2003. These data are taken from a sample of households that are demographically balanced within 53 markets (cities and rural markets) and four Census regions in the United States. About 85% of households represented city markets and about 15% of households were from rural markets. Major city markets were Chicago, Los Angeles, New York, San Francisco, Atlanta, Philadelphia, Baltimore, Washington DC and San Antonio.

Each household was provided with a scanner machine in which they could scan and record all items purchased in different retail trade locations throughout a given time period. Panelists recorded the expenditure and quantity of all items purchased in that household followed by input of demographic information about the household.

ACNielsen Homescan data include purchases of all consumer items bought by a household during a specified period of time. However, for our analysis, we used nationally representative purchase data only for food and beverage items. As exhibited in. Initially, monthly household purchases of nonalcoholic beverages (expenditure and quantity information) are generated for each household in the Nielsen HomeScan Panel data over the period January 1998 through December 2003. Next, the expenditure and quantity data are summed over all households for each month for each of the aforementioned nonalcoholic beverage categories. As such, we generate monthly purchase data to arrive at a total of 72 observations (72 months) for each nonalcoholic beverage category. Quantity data are standardized in terms of gallons for all nonalcoholic beverages considered in this study and expenditure data are expressed in terms of dollars. Taking into account household size and the U.S. population numbers for every month from January 1998 through December 2003, our volume data and expenditure data are expressed in terms of gallons purchased and dollars spent per person per month. Then taking the ratio of expenditure to volume, we generate unit values (or price) for each nonalcoholic beverage category for each month. These prices were adjusted for inflation using the consumer price index data (CPI) for each month to generate a real price series for each beverage category. Using real prices and monthly per capita consumption values, finally we generate expenditure share information for the ten nonalcoholic categories previously discussed. The real per capita total expenditure was generated using real price and per capita consumption of all ten nonalcoholic beverages put together.

We are not aware of past efforts to generate this type of time-series data for the purpose of conducting demand analyses. To lend support to this approach, we find strong correlations of our data on an annual basis with annual USDA Economic Research Service disappearance data (also called food supply data or food availability data) for similar beverage categories. Even though we lose household demographic information with this aggregation, we do not encounter data censoring problems inherent in trying to use micro-level data in estimating demand systems.

Model

We employ an almost ideal demand system (AIDS) model developed by Deaton and Muelbauer (1980) to capture interrelationships among nonalcoholic beverage categories. Above model was selected because it has many desirable properties over other systems approaches. Some of them include the ability of AIDS model to give an arbitrary first-order approximation to any demand system, exact satisfaction of axioms of choice, perfect aggregation over consumers (households in this study) without invoking parallel linear Engle Curves and simplicity of estimation. Own-price and cross-price demand elasticities are estimated for the ten beverage categories over the 72-month period. We posited the following AIDS model with an additive disturbance term and a seasonal adjustment done using quarterly seasonal dummies.

$$(1) \qquad w_{it} = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln p_{jt} + \beta_i [\ln m - \ln a(P)] + \sum_{j=1}^{3} d_j Q_{ijt} + e_{it} ,$$

where the price index P is defined by,

$$(2) \qquad \ln a(P) = \alpha_0 + \sum_{i=1}^{n} \alpha_i \ln p_i + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} \ln p_i \ln p_j ,$$

where i(=1,2,….,10) indexes 10 nonalcoholic beverages categories in the system, t indexes the time in months (there are 72 months in this study), p_{jt} is monthly real prices for each nonalcoholic beverage considered in study, m is the real per capita total expenditure calculated using real price, p_{jt} and per capita quantity consumed in each nonalcoholic beverage, q_{it} . Q_{ijt} is the quarterly dummy used to capture the seasonality pertaining to four quarters of the year. Monthly budget share of each nonalcoholic beverage consumed is denoted by w_{it} where $w_{it} = \frac{p_{it} q_{it}}{m}$. Additive disturbance term is denoted by e_{it} . In the table 1, we show the variable definitions and summary statistics for the data used in this study.

Model Estimation

The model was estimated using SAS 9.2 statistical software. We used the Proc Model procedure to estimate model parameters and subsequently to calculate expenditure, own-price and cross-price elasticities. Possible endogeneity issue with the real per capita total expenditure was removed through predictions of real per capita total expenditure (*m_hat*) obtained through an auxiliary regression. In the auxiliary regression, natural log of per capita real total expenditure was regressed on two instruments; natural log of real price, $\ln p_{jt}$ and natural log of real per capita income, $\ln inc_{it}$ using Proc Autoreg procedure in SAS 9.2. Random disturbance term is denoted by k_{it}. Thus predicted values were used as real per capita total expenditure in the AIDS model (variable *m* in above equation (1)) above. The auxiliary regression used is as follows;

$$(3) \qquad \ln m_{it} = c_0 + \sum_{j=1}^{n} c_{ij} \ln p_{jt} + c_{11} \ln inc_{it} + k_{it}$$

Furthermore, we corrected above auxiliary regression for autocorrelation with an AR(1) process of the disturbance term.

The Durbin-Watson statistics obtained for the AIDS model estimation indicated the presence of possible serial (auto) correlation (this was expected given the time series nature of the data set). We therefore, estimated the AIDS model with an AR(2) process:

$$(4) \qquad e_{it} = \rho_{i1} e_{i,t-1} + \rho_{i2} e_{i,t-2} + u_{it} \,,$$

where ρ_{i1} and ρ_{i2} are fist and second order autoregressive parameters respectively. The white-noise disturbance term is denoted by u_{it}. Each budget share equation in the system is modeled as an AR(2) process.

In estimating the AIDS model, we impose theoretical restrictions on parameters such as, adding-up:

$$(5) \qquad \sum_{i=1}^{n} \alpha_i = 1, \sum_{i=1}^{n} \beta_i = 0, \sum_{j=1}^{n} \gamma_{ij} = 0 \,,$$

homogeneity:

$$(6) \qquad \sum_{j=1}^{n} \gamma_{ij} = 0,$$

and symmetry:

$$(7) \qquad \gamma_{ij} = \gamma_{ji}.$$

Given the fact that all expenditure shares add up to one, i.e. $\sum_{i=1}^{10} w_{it} = 1$, and above adding up conditions, we estimate the AIDS model with only 9 equations (dropping the budget share equation pertaining to tea consumption) to avoid the singularity of the error variance-covariance matrix. The parameters of the tea budget share equation was recovered using adding-up restrictions.

We estimated the AIDS model using Zellner's iterative seemingly unrelated regression (ITSUR) procedure with homogeneity, symmetry and adding-up restrictions imposed on parameters. Given the size of the data set, the significance level used in our study was 10% (*p*-value 0.10).

Empirical Results and Discussion

In the following section, first we offer a brief narrative on variable definitions and summary statistics. Second, AIDS model parameters estimated imposing theoretical restrictions are presented and discussed. Third, we offer a discussion on calculation of expenditure, own-price and cross-price elasticities for ten nonalcoholic beverages considered in this study. Finally, we compare our results from similar work done in the past literature.

Summary Statistics

According to table 1, during the period January 1998 through December 2003, on average, the most heavily consumed nonalcoholic beverage per month at-home was coffee. It was consumed at the rate of 0.93 gallons per person per month. Coffee was followed by regular soft drinks (non-diet type) where 0.91 gallons per person per month was consumed. At-home per capita high-fat and low-fat milk consumption per month on average was 0.53 gallons and 0.38 gallons respectively. On average, per capita bottled water consumption at-home was 0.35 gallons per month. Isotonics (energy drinks like Gatorade and RedBull) was the least consumed nonalcoholic beverage at-home and averages about 0.03 gallons per person per month.

Isotonics and fruit juices were the most expensive nonalcoholic beverages consumed during the period considered and they were, on average, \$2.55 per gallon and \$2.45 per gallon respectively (current market prices may be higher, because these prices reported in table 1 are real prices adjusted for inflation using consumer price index; CPI, base year 1983-1984=100). Gallon of coffee was the least expensive, costing only \$0.61.

On average, as a single category, the highest budget share is associated with consumption of regular soft drinks at-home (20%) and lowest being the consumption of isotonics (1%). At-home average budget share for fruit juice stands at second highest next to regular soft drinks (18%). Per capita real total expenditure for all of ten nonalcoholic beverages consumed at-home was on average \$1.82 per month.

AIDS Model Parameter Estimates

Parameter estimates of AIDS model are reported in table 2 below. Table 3 shows the adjusted R-Square and Durbin-Watson (DW) statistics estimated for each budget share equation after modeling the AIDS model as an AR(2) process of error term. Looking at the adjusted R-Squares and DW statistics, we can state that the results were satisfactory. Bottled water budget share equation produced the highest R-Square (0.91) while diet soft drinks gave the lowest (0.26). Out of fifty five own and cross-price coefficients estimated, thirty one were statistically significant at 10% level. Eight out of ten intercept coefficients (alphas) and eight out of nine expenditure coefficients (betas) were statistically significant at 10% level. Coefficients associated with seasonal dummies (the *d*'s) showed higher budget shares coupled with second and third quarter for nonalcoholic beverages considered in this study, compared to the forth quarter. Second and third quarter seasonal dummies were statistically significant at 10% level. Each budget share equation was entertained with an AR(2) correction for possible autocorrelation problem in the data. Autocorrelation coefficients estimated (the rho's) for first and second order autocorrelation of error terms were significant at 10% for most of budget share equations considered.

Auxiliary Regression of Total Expenditure

Table 4 shows the results for the auxiliary regression run to circumvent possible endogeniety problem associated with the per capital real total expenditure variable (the dependent variable considered in the study was natural log of real per capita total expenditure in dollars per month). The R-Squared and DW statistics for the estimated auxiliary regression were 0.85 and 2.10 respectively. The predicted values of real per capita total expenditure estimated using parameters values generated from auxiliary regression were used in estimating AIDS model, thereby correcting for possible endogeneity issues inherent with total expenditure variable.

Elasticity Estimates

Based on the parameter estimates from table 2, we calculated expenditure, and uncompensated and compensated own-price and cross-price elasticities for ten nonalcoholic beverages considered in this study. In calculating elasticities, the local coordinate for the budget share for each nonalcoholic beverage was taken as the average of the final 12 observations from each expenditure share data series. This was done due to the fact that the average over all 72 observations for each budget share series was not a best predictor for the next period concerned. That is to say, some budget share series are highly non-stationary and moving away from the historical mean and therefore, the sample mean was not a best local coordinate to evaluate elasticities on. We used elasticity formulas derived for AIDS model in the literature as follows. Equation (8) below was used to calculate expenditure elasticities η_i 's. w_i and w_j are the average budget shares taking into account the final 12 observations from each budget share series.

$$(8) \qquad \eta_i = \frac{\beta_i}{w_i} + 1$$

The uncompensated price elasticities are given by equation (9) below.

$$(9) \qquad \varepsilon_{ij}^U = \frac{[\gamma_{ij} - \beta_i(\alpha_j + \sum_{k=1}^{n} \gamma_{jk} \ln p_k)]}{w_i} - \delta_{ij},$$

where, δ_{ij} is Kronecker delta where, $\delta_{ij} = 1$ if $i = j$ and $\delta_{ij} = 0$ if $i \neq j$. Compensated price elasticities were generated through the elasticity form of the Slutsky equation (equation (10) below), where ε_{ij}^C is the compensated price elasticity of demand.

$$(10) \qquad \varepsilon_{ij}^C = \varepsilon_{ij}^U + \eta_i w_j$$

It should be noted that all elasticity estimates are conditional elasticities in that they were generated under exogenous real expenditures and real prices. Uncompensated cross-price elasticities show the gross substitution and gross complementary effects while its compensated counterpart distinguishes between net substitutes and net complements. Expenditure elasticity reveals the change in the consumption of a given nonalcoholic beverage for a change in expenditure on each item.

Table 5 shows the calculated uncompensated and compensated own-price and cross-price elasticities, expenditure elasticities and budget shares on last 12 observations for each nonalcoholic beverage category.

Calculated expenditure elasticities reveal that, isotonics is the most elastic good where one percent increase in the expenditure on nonalcoholic beverages would increase demand for isotonics by 2.6 percent, *cetris-paribus*. It is important to understand that our results do not imply that isotonics is a luxury good since expenditure elasticities are different from unconditional income elasticities. Regular and diet soft drinks are expenditure elastic where expenditure elasticities are 1.5 and 1.27 respectively. Bottled water having an expenditure elasticity of 0.36, on the other hand, is the most expenditure inelastic beverage category. It should be noted that all expenditure elasticities are significant at p-value 0.10 (or 10% level).

All uncompensated and compensated own-price elasticities of demand have theoretically coherent negative sign. Every one but fruit drinks and bottled water own-price elasticities of demand are statistically different from zero at 10% level. Isotonics is the most price sensitive beverage category, having a compensated own-price elasticity of demand of -5.94. Even though there is a small budget share associated with isotonics (approximately one percent) compared to other nonalcoholic beverages, they are the most expensive out of the ten nonalcoholic beverages considered in this study. Given this high price of isotonics, the marginal consumer is more sensitive to its demand. The compensated own-price elasticity of demand for regular soft drinks is -1.90, indicating an elastic nature of demand. Rest of the beverage categories considered is inelastic in demand (looking at compensated own-price elasticities of demand).

Thirty six out of ninety (forty percent) compensated cross-price elasticities have negative sign indicating net complements. Sixty percent of compensated cross-price elasticities are indicative of net substitutes. In particular, coffee is the strongest net substitute for isotonics. Fruit drinks and diet soft drinks are net complements to regular soft drinks. Milk (high-fat and low-fat), fruit juices, bottled water, coffee, isotonics and tea are net substitutes for regular soft drinks. Diet soft drinks are a net substitute for all beverages considered but regular soft drinks. Milk (high-fat and low-fat) is a net complement for fruit drinks, fruit juices, bottled water and tea. This result is probably justifiable looking at breakfast choices of consumers. Most of consumer may consume fruit drinks, fruit juices, water or tea along with milk at breakfast. Coffee is a net complement of fruit juice, fruit drinks, water and tea. Again, most consumers may consume fruit juice, fruit drinks, water, or tea with coffee at breakfast. We also find that high-fat milk is a net substitute for low-fat milk. Fruit juices and fruit drinks are too net substitutes.

Comparison with other Studies in the Literature

The purpose of table 6 is to compare our results with similar studies done on nonalcoholic beverages in the past (we compare ours with 4 past studies). It should be stressed that to our knowledge, ours is the first study that models demand for nonalcoholic beverages in a systemwide framework with such a rich delineation of beverages categories. All past studies had only 4 nonalcoholic beverage categories, namely, milk, juice, soft drinks, bottled water and tea/coffee (combined). Our study has 10 nonalcoholic beverage categories and other than bottled water (which is cited in the past literature), our study has 9 unique categories that have not studied in the past. We have two separate categories each for milk (high-fat and low-fat), soft drinks (regular and diet), and fruit beverages (fruit drinks and fruit juices). We also treat tea and coffee in two separate categories. Inclusion of isotonics (sport and energy drinks) in our beverage list is a very unique move.

Three out of four past studies used annual time series data (Zheng and Kaiser, 2008 and Kinnucan et al. 2001) and one study used a cross sectional data set from 1996-97 (Yen et al. 2004). Our unique data set spans over 72 monthly observations starting at January 1998 and ending at December 2003. Given the 6 year period, our data set is more immune to effects from structural change compared to data spanning over a 30 year period as used in previous studies. In addition to that, given the nature of monthly observations in our possession, we were in a position to explore quarterly seasonal variability of data, which we found highly significant.

The overall implication of table 6 is that all compensated and uncompensated own-price elasticities gave theoretically consistent negative sign and statistical significance at 5% level except for fruit drinks and bottled water in our study with respect to statistical significance and bottled water in Zheng and Kaiser (2008) Rotterdam model with respect to sign and statistical significance. Owing to the short time series studied in our data set, we observe consistently higher own-price elasticities compared to other models that used time series data with a longer time span. Our tea and coffee expenditure elasticities are more comparable with Kinnucan et al. (2001) and Yen et al. (2004) than to Zheng and Kaiser (2008).

Conclusions

In this study we modeled demand for nonalcoholic beverages using a unique data set developed using Nielsen HomeScan panel data of household purchases of nonalcoholic beverages over the period January 1998 through December 2003. We used 72 monthly observations of expenditure shares, real prices and real per capita expenditures of 10 unique categories of nonalcoholic beverages in a full-blown AIDS model with an adjustment for seasonal (quarterly) variability in data.

In comparison to similar studies done in the past literature, our study uses a rich delineation of nonalcoholic beverage categories, and in particular introduced isotonics for the first time. Furthermore, our study provided more information about important sub categories of nonalcoholic beverages, such as, regular and diet soft drink partition to soft drink category, high-fat and low-fat partition to milk category, and fruit drinks and fruit juices in fruit beverages category. It also separates the effects of tea and coffee, unlike past studies in the literature where both tea and coffee are analyzed as a single category.

All own-price elasticities we estimated were theoretically consistent sign-wise (negative sign) and majority of compensated cross-price elasticities revealed that most of (60%) of nonalcoholic beverages were net substitutes. We found that isotonics were the most price and expenditure elastic nonalcoholic beverage and it is followed by regular soft drinks. Furthermore, milk was found to be net complements with fruit drinks, fruit juices, water, and tea. Additionally, diet and regular soft drinks were also net complements. Fruit juice and fruit drinks were found to be net substitutes. Our study further shows that consumers also substituted high fat milk with low fat milk.

Limitations of Our Study

A limitation of our study is that we can only capture the at-home consumption of nonalcoholic beverages and their interrelationships. The Nielsen HomeScan Panels pertain to at-home consumption only. But these data do allow a different way of capturing patterns of nonalcoholic beverage consumption through time. In this way, more refined categories of nonalcoholic beverages can be considered without the econometric issues associated with micro-level data. Moreover, our technique of assembling these data over time could take into account region, race, and income depending on the sorting process.

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Table 1: Variable Definitions and Summary Statistics: January 1998-Dcember 2003

Variable	Definition	Mean	Std Dev	Minimum	Maximum
Qiso	Per capita isotonics consumption, gallons/month	0.03	0.013	0.01	0.06
Qrsd	Per capita regular soft drinks consumption, gallons/month	0.91	0.126	0.66	1.24
Qdsd	Per capita diet soft drinks consumption, gallons/month	0.56	0.060	0.45	0.72
Qhfm	Per capita high fat milk consumption, gallons/month	0.53	0.061	0.39	0.67
Qlfm	Per capita low fat milk consumption, gallons/month	0.38	0.069	0.26	0.53
Qfd	Per capita fruit drinks consumption, gallons/month	0.23	0.037	0.15	0.29
Qfj	Per capita fruit juice consumption, gallons/month	0.45	0.053	0.34	0.55
Qbw	Per capita bottled water consumption, gallons/month	0.35	0.072	0.19	0.52
Qcof	Per capita coffee consumption, gallons/month	0.93	0.128	0.67	1.15
Qtea	Per capita tea consumption, gallons/ month	0.34	0.034	0.28	0.42
Piso	Real price of isotonics, $/gallon	2.55	0.177	2.24	3.01
Prsd	Real price of regular soft drinks, $/gallon	1.38	0.046	1.28	1.48
Pdsd	Real price of diet soft drinks, $/gallon	1.38	0.045	1.30	1.49
Phfm	Real price of high fat milk, $/gallon	1.60	0.061	1.49	1.76
Plfm	Real price of low fat milk, $/gallon	1.59	0.057	1.47	1.74
Pfd	Real price of fruit drinks, $/gallon	1.91	0.083	1.75	2.06
Pfj	Real price of fruit juice, $/gallon	2.45	0.068	2.29	2.59
Pbw	Real price of bottled water, $/gallon	0.78	0.049	0.66	0.86
Pcof	Real price of coffee, $/gallon	0.61	0.064	0.52	0.75
Ptea	Real price of tea, $/gallon	0.78	0.045	0.68	0.91
Wiso	Budget share isotonics	0.01	0.004	0.01	0.02
Wrsd	Budget share regular soft drinks	0.20	0.013	0.17	0.23
Wdsd	Budget share diet soft drinks	0.13	0.006	0.11	0.14
Whfm	Budget share high fat milk	0.14	0.007	0.12	0.15
Wlfm	Budget share low fat milk	0.10	0.009	0.08	0.12
Wfd	Budget share fruit drinks	0.07	0.009	0.05	0.09
Wfj	Budget share fruit juice	0.18	0.013	0.15	0.20
Wbw	Budget share bottled water	0.05	0.015	0.02	0.08
Wcof	Budget share coffee	0.09	0.011	0.07	0.11
Wtea	Budget share tea	0.04	0.005	0.03	0.05
Lte	Per capita real total expenditure, $/month	1.82	0.122	1.49	2.06

Table 2: Parameter Estimates of AIDS model for U.S. Nonalcoholic Beverages Consumed At-Home: January 1998-December 2003

Parameter	Estimate	Std Error	t Value	Pr > |t|
γ_{11}	**-0.04612**	0.00693	-6.66	<.0001
γ_{12}	-0.00084	0.0128	-0.07	0.9479
γ_{13}	0.013392	0.0117	1.14	0.2575
γ_{14}	0.005563	0.00703	0.79	0.4319
γ_{15}	-0.00601	0.00594	-1.01	0.3151
γ_{16}	**-0.01241**	0.00692	-1.79	0.0776
γ_{17}	0.015679	0.011	1.43	0.1573
γ_{18}	0.007528	0.00552	1.36	0.1778
γ_{19}	**0.021451**	0.00501	4.28	<.0001
γ_{110}	0.001776	0.00418	0.42	0.6726
γ_{22}	**-0.22032**	0.0566	-3.89	0.0002
γ_{23}	**-0.12524**	0.0404	-3.1	0.0029
γ_{24}	**0.072662**	0.0221	3.3	0.0016
γ_{25}	**0.039385**	0.0211	1.87	0.0661
γ_{26}	**-0.03296**	0.0195	-1.69	0.0954
γ_{27}	**0.194957**	0.0358	5.45	<.0001
γ_{28}	0.006164	0.0179	0.35	0.7311
γ_{29}	**0.046714**	0.0187	2.49	0.0153
γ_{210}	0.019473	0.013	1.5	0.1397
γ_{33}	-0.01349	0.0418	-0.32	0.7481
γ_{34}	0.030259	0.0207	1.46	0.1483
γ_{35}	0.013216	0.0192	0.69	0.4945
γ_{36}	**0.040504**	0.0169	2.39	0.0198
γ_{37}	0.013726	0.0251	0.55	0.5867
γ_{38}	**0.038694**	0.0126	3.07	0.0032
γ_{39}	-0.00579	0.0129	-0.45	0.6542
γ_{310}	-0.00527	0.00939	-0.56	0.5766
γ_{44}	0.016657	0.0267	0.62	0.5352
γ_{45}	0.028861	0.0232	1.24	0.2189
γ_{46}	**-0.04434**	0.0113	-3.93	0.0002

γ_{47}	**-0.05755**	0.0171	-3.37	0.0013
γ_{48}	**-0.0153**	0.0087	-1.76	0.0833
γ_{49}	-0.00521	0.0086	-0.61	0.5469
γ_{410}	**-0.0316**	0.00613	-5.15	<.0001
γ_{55}	0.013349	0.0242	0.55	0.5835
γ_{56}	**-0.0208**	0.00979	-2.13	0.0375
γ_{57}	**-0.03693**	0.0124	-2.99	0.004
γ_{58}	**-0.04782**	0.00656	-7.29	<.0001
γ_{59}	**0.037962**	0.00604	6.29	<.0001
γ_{510}	**-0.02121**	0.00531	-4	0.0002
γ_{66}	**0.063429**	0.015	4.24	<.0001
γ_{67}	-0.00946	0.0164	-0.58	0.5653
γ_{68}	**0.033651**	0.00977	3.44	0.001
γ_{69}	**-0.02611**	0.0106	-2.47	0.0163
γ_{610}	0.008494	0.00624	1.36	0.1782
γ_{77}	-0.00389	0.0401	-0.1	0.923
γ_{78}	**-0.05787**	0.0163	-3.55	0.0007
γ_{79}	**-0.03981**	0.0168	-2.37	0.021
γ_{710}	-0.01886	0.0127	-1.49	0.1422
γ_{88}	**0.055042**	0.0127	4.35	<.0001
γ_{89}	**-0.05605**	0.0097	-5.78	<.0001
γ_{810}	**0.035964**	0.00693	5.19	<.0001
γ_{99}	**0.036533**	0.014	2.6	0.0115
γ_{910}	-0.0097	0.00697	-1.39	0.1688
γ_{1010}	**0.020939**	0.00702	2.98	0.0041
α_1	**0.034156**	0.013	2.62	0.011
α_2	-0.01136	0.0488	-0.23	0.8166
α_3	0.047916	0.0333	1.44	0.1555
α_4	**0.184996**	0.0227	8.17	<.0001
α_5	**0.106695**	0.0158	6.76	<.0001
α_6	**0.044276**	0.023	1.92	0.0592
α_7	**0.203895**	0.0475	4.3	<.0001
α_8	**0.141857**	0.0249	5.7	<.0001
α_9	**0.146084**	0.0295	4.95	<.0001
α_{10}	**0.101482**	0.018	5.63	<.0001

β_1	**0.014854**	0.00514	2.89	0.0053
β_2	**0.096564**	0.0237	4.07	0.0001
β_3	**0.036225**	0.0145	2.51	0.0148
β_4	**-0.02694**	0.00992	-2.72	0.0085
β_5	0.005289	0.00695	0.76	0.4495
β_6	**0.019739**	0.0105	1.88	0.0651
β_7	**-0.06048**	0.0207	-2.93	0.0048
β_8	**-0.04204**	0.012	-3.51	0.0008
β_9	**-0.03138**	0.014	-2.23	0.029
d1	-0.00006	0.000131	-0.48	0.632
d2	**0.000312**	0.000154	2.02	0.0474
d3	**0.000449**	0.000125	3.6	0.0006
ρ_{11}	**0.389798**	0.0959	4.06	0.0001
ρ_{12}	**0.308544**	0.0954	3.23	0.0019
ρ_{21}	**0.508445**	0.0624	8.15	<.0001
ρ_{22}	**0.122068**	0.0642	1.9	0.0618
ρ_{31}	**0.407631**	0.0712	5.72	<.0001
ρ_{32}	**0.296799**	0.0679	4.37	<.0001
ρ_{41}	**0.58575**	0.0744	7.88	<.0001
ρ_{42}	0.098597	0.0749	1.32	0.1926
ρ_{51}	**0.269623**	0.0807	3.34	0.0014
ρ_{52}	0.092604	0.0793	1.17	0.2471
ρ_{61}	**0.811419**	0.0729	11.14	<.0001
ρ_{62}	**-0.19389**	0.069	-2.81	0.0066
ρ_{71}	**0.497831**	0.0694	7.17	<.0001
ρ_{72}	**0.167693**	0.0674	2.49	0.0155
ρ_{81}	**0.535892**	0.0694	7.73	<.0001
ρ_{82}	**0.155865**	0.0669	2.33	0.023
ρ_{91}	**0.589374**	0.0762	7.74	<.0001
ρ_{92}	0.024163	0.0772	0.31	0.7554

Note: all estimated coefficients in bold are significant at 10% level

Table 3: Adjusted R-Squared and Durbin-Watson Statistics for each Budget Share Equation Estimated in the AIDS model

Budget Share Equation	Adjusted R-Squared	Durbin-Watson Statistic (DW)
Isotonics	0.86	1.51
Regular Soft Drinks	0.51	1.86
Diet Soft Drinks	0.26	1.68
High Fat Milk	0.68	1.67
Low Fat Milk	0.87	1.66
Fruit Drinks	0.74	1.57
Fruit Juice	0.62	1.12
Bottled Water	0.91	1.50
Coffee	0.72	1.53

Table 4: Auxiliary Regression of Total Expenditure

Variable	Definition	Estimate	Standard Error	t Value	Pr > |t|
Intercept		**23.4938**	4.8188	4.88	<.0001
Lpiso	Natural log of real price, Isotonics	0.1861	0.2232	0.83	0.4079
Lprsd	Natural log of real price, Regular Soft Drinks	**1.4858**	0.7742	1.92	0.0599
Lpdsd	Natural log of real price, Diet Soft Drinks	-0.2083	0.8471	-0.25	0.8067
Lphfm	Natural log of real price, High Fat Milk	**1.3299**	0.7834	1.7	0.0949
Lplfm	Natural log of real price, Low Fat Milk	-1.0476	0.8098	-1.29	0.2009
Lpfd	Natural log of real price, Fruit Drinks	0.2116	0.3425	0.62	0.5392
Lpfj	Natural log of real price, Fruit Juice	0.4587	0.3038	1.51	0.1366
Lpbw	Natural log of real price, Bottled Water	**0.5557**	0.2068	2.69	0.0094
Lpcof	Natural log of real price, Coffee	0.0807	0.1398	0.58	0.5657
Lptea	Natural log of real price, Tea	0.1667	0.1661	1	0.3196
Linc	Natural log of real per capita income	**-2.3668**	0.4957	-4.77	<.0001

Table 5: Own-Price, Cross-Price and Expenditure Elasticities Estimated through AIDS Model

Uncompensated demand elasticities											
	Isotonics	**Regular soft drinks**	**Diet soft drinks**	**High fat milk**	**Low fat milk**	**Fruit Drinks**	**Fruit Juices**	**Bottled Water**	**Coffee**	**Tea**	**Expenditure elasticity**
Isotonics	**-5.961**	-0.203	1.321	0.315	-0.785	**-1.402**	1.286	0.633	**2.100**	0.092	**2.604**
Regular soft drinks	0.0003	**-2.190**	**-0.696**	**0.291**	0.164	**-0.192**	**0.893**	-0.025	**0.177**	0.071	**1.506**
Diet soft drinks	0.1055	**-0.969**	**-1.125**	0.182	0.077	**0.298**	0.035	**0.264**	-0.081	-0.057	**1.276**
High fat milk	0.0386	**0.550**	0.241	**-0.839**	0.233	**-0.324**	**-0.380**	-0.092	-0.012	**-0.224**	**0.798**
Low fat milk	-0.0674	**0.436**	0.143	0.315	**-0.855**	**-0.236**	**-0.430**	**-0.544**	**0.419**	**-0.242**	**1.059**
Fruit Drinks	**-0.1576**	**-0.433**	**0.515**	**-0.629**	**-0.293**	-0.178	-0.190	**0.412**	**-0.377**	0.095	**1.259**
Fruit Juices	0.0872	-0.049	0.109	**-0.274**	**-0.186**	-0.037	**-0.933**	**-0.297**	**-0.184**	-0.088	**0.649**
Bottled Water	0.1096	0.147	**0.645**	-0.128	**-0.672**	**0.545**	**-0.725**	-0.093	**-0.764**	**0.585**	**0.362**
Coffee	**0.2488**	**0.567**	-0.042	0.004	**0.480**	**-0.293**	**-0.371**	**-0.615**	**-0.517**	-0.092	**0.628**
Tea	0.0350	0.427	-0.089	**-0.623**	**-0.425**	0.191	-0.335	**0.785**	-0.173	**-0.544**	**0.752**

Note: Elasticity values in bold font are significant at 10% level

Table 5 Continued

Compensated Demand elasticities										
	Isotonics	**Regular soft drinks**	**Diet soft drinks**	**High fat milk**	**Low fat milk**	**Fruit Drinks**	**Fruit Juices**	**Bottled Water**	**Coffee**	**Tea**
Isotonics	**-5.937**	0.294	1.662	0.663	-0.553	-1.203	1.734	0.804	**2.320**	0.216
Regular soft drinks	0.0143	**-1.903**	**-0.499**	**0.492**	**0.298**	-0.077	**1.153**	**0.075**	**0.304**	0.142
Diet soft drinks	0.1173	**-0.726**	**-0.957**	**0.352**	0.191	**0.396**	0.254	**0.348**	0.026	0.003
High fat milk	0.0460	**0.703**	**0.346**	**-0.733**	**0.304**	**-0.264**	**-0.242**	-0.039	0.056	**-0.186**
Low fat milk	-0.0576	**0.638**	0.282	**0.457**	**-0.761**	-0.155	**-0.248**	**-0.474**	**0.508**	**-0.192**
Fruit Drinks	-0.1460	-0.193	**0.680**	**-0.461**	-0.181	-0.082	0.027	**0.495**	**-0.271**	**0.155**
Fruit Juices	0.0932	0.075	0.194	**-0.188**	**-0.128**	0.012	**-0.822**	**-0.254**	-0.129	-0.057
Bottled Water	0.1129	0.216	**0.692**	-0.080	**-0.640**	**0.573**	**-0.663**	-0.070	**-0.733**	**0.602**
Coffee	**0.2546**	**0.686**	0.041	0.088	**0.536**	**-0.245**	-0.263	**-0.573**	**-0.464**	-0.062
Tea	0.0420	**0.570**	0.009	**-0.522**	**-0.359**	**0.249**	-0.206	**0.835**	-0.110	**-0.509**

Note: Elasticity values in bold font are significant at 10% level

Table 6: Comparison of Price and Expenditure Elasticities with other Studies in the Literature

				Own-price elasticities		
	Model	**Data**	**Products**	**Compensated Price**	**Uncompensated Price**	**Expenditure Elasticities**
Our Study	Full-blown AIDS model	Monthly time series January 1998-December 2003	Isotonics	-5.937**	-5.961**	2.604**
			Regular soft drinks	-1.903**	-2.190**	1.506**
			Diet soft drinks	-0.957**	-1.125**	1.276**
			High-fat milk	-0.733**	-0.839**	0.798**
			Low-fat milk	-0.761**	-0.855**	1.059**
			Fruit drinks	-0.082	-0.178	1.259**
			Fruit juices	-0.822*	-0.933**	0.649**
			Bottled water	-0.070	-0.093	0.364**
			Coffee	-0.464**	-0.517**	0.628**
			Tea	-0.509**	-0.544**	0.752**
Zheng and Kaiser (2008)	LA-AIDS model	Annual time series 1974-2005	Soft drinks	-0.151**	-0.521**	0.997
			Milk	-0.154**	-0.301**	0.614**
			Juice	-0.172**	-0.272	0.656
			Bottled water	-0.498**	-0.501**	0.029
			Coffee/tea	-0.083**	-0.462**	3.144**
Zheng and Kaiser 2008	Rotterdam model	Annual time series 1974-2005	Soft drinks	-0.164**	-0.306**	0.381**
			Milk	-0.102**	-0.161**	0.243**
			Juice	-0.458**	-0.898**	2.891**
			Bottled water	0.044	0.051	0.062**
			Coffee/tea	-0.260**	-0.628**	3.049**

** indicates significance at 10% level

Table 6 Continued.

				Own-price elasticities		
	Model	Data	Products	Compensated Price	Uncompensated Price	Expenditure Elasticities
Kinnucan et al. 2001	Rotterdam model	Annual time series 1970-1994	Soft drinks	-0.137**	-0.675**	1.238**
			Milk	-0.169**	-0.283**	0.406**
			Juice	-0.361**	-0.471**	0.698
			Bottled water	--	--	--
			Coffee/tea	-0.249**	-0.487**	1.876**
Yen et al. 2004	Translog demand system	National Food Stamp Program Survey, 1996-97, 908 obs	Soft drinks	-0.520**	-0.800**	1.010**
			Milk	-0.590**	-0.690**	0.800**
			Juice	-0.350**	-0.520**	0.900**
			Bottled water	--	--	--
			Coffee/tea	-0.470**	-0.890**	1.130**

** indicates significance at 10% level