OPEN ACCESS

International Journal of Social Sciences and Management

A Rapid Publishing Journal

ISSN 2091-2986

Indexing and Abstracting

CrossRef, Google Scholar, International Society of Universal Research in Sciences (EyeSource), Journal TOCs, New Jour, Scientific Indexing Services, InfoBase Index, Open Academic Journals Index (OAJI), Scholarsteer, Jour Informatics, Directory of Research Journals Indexing (DRJI), International Society for Research Activity (ISRA): Journal Impact Factor (JIF), Simon Fraser University Library, etc.

Vol- 3(1), January 2016

SEM-Biotech Publishing

Impact factor*: **3.389**

*Impact factor is issued by SJIF INNO SPACE. Kindly note that this is not the IF of Journal Citation Report (JCR).

K.P. Pokharel (2016) Int. J. Soc. Sci. Manage. Vol-3, issue-1: 38-46
DOI: 10.3126/ijssm.v3i1.13813

ISSN 2091-2986
DOI Prefix: 10.3126/ijssm
International Journal of Social Sciences and Management (IJSSM)

Research Article

DEMAND ANALYSIS FOR NON- ALCOHOLIC BEVERAGES CONSUMPTION IN THE UNITED STATES

Krishna Prasad Pokharel[1*]

[1]Department of Agricultural Economics, Kansas State University, Manhattan, KS, 66506, USA

[*]Corresponding author email: kpokharel@ksu.edu

Abstract

This research analyzes the demand for non-alcoholic beverages (non-diet carbonated beverages, diet carbonated beverages, non-carbonated caloric beverages, water, and unsweetened coffee and tea) in the United States using the first difference version of the Almost Ideal Demand System model. Five expenditure shares and prices demand equations for the non-alcoholic beverages are estimated using the Iterated Seemingly Unrelated Regression (ITSUR) and Full Information Maximum Likelihood (FIML) techniques. These two estimation techniques give similar results. Most of the products exhibit the consistent sign for the own and cross price elasticities as predicted by economic theory. Based on the expenditure elasticity, non-diet beverage is a luxury good (1.632) and the remaining goods have expenditure elasticity less than, which indicates that these products are necessities. These products are not weakly separable based on the regular and adjusted Wald tests. Moreover, seasonality has a positive impact on caloric beverages and water and a negative impact on the remaining products.

Keywords: non-alcoholic beverages; AIDS; ITSUR; FIML; elasticity.

Introduction

Consumers have been consuming non-alcoholic beverages for many centuries over the globe and the non-alcoholic beverage industry is one of the largest industries in the world accounting for 531.3 billion dollars of transactions in 2013 (Euromonitor, 2014). Moreover, the non-alcoholic beverage is one of the sources of nutrients. For example, the consumption of beverages (milk, carbonated soft drinks, bottled water, fruit juices, fruit drinks, coffee, tea, and sports drinks) accounts for 10% for calories, 20% for calcium, and 70% for vitamin C in a daily value basis in the Unites States (Capps *et al.*, 2005) and people are more sensitive towards food consumption due to health concerns in recent decades. The increasing awareness about health in recent years led to the production of healthier food choices. To be specific, beverage producers have started to provide new healthier non-alcoholic beverages like non-diet carbonated beverages, unsweetened coffee and tea etc., which may significantly change the consumption patterns of non-alcoholic beverages. According to the Economic Research Service, United States Department of Agriculture (ERS USDA, 2009) report, there was a substantial change in the consumption pattern of non-alcoholic beverages. For instance, per capita consumption of bottled water increased from 1.6 gallons per year in 1976 to 29 gallons per year in 2007. The consumption of soft drinks has increased approximately by 60% from 1980 to 1998 and thereafter a slight decrease toward 2007. Similarly, the per capita coffee consumption has decreased by 26% from 1970 to 2009 in the United States (Dharmasena and Capps, 2009).

The demand for non-alcoholic beverages is complex and changes over time with the introduction of new products in the market. Various factors including tastes, preferences, demography, advertising, temperatures, and convenient availability of new differentiated products may affect the consumption pattern of these goods (Yohannes and Matsuda, 2015; Arnade *et al.*, 2004; Kaiser and Reberte, 1996). For example, availability of bottled water may increase the demand for water and could decrease the coffee consumption (BLS, 2003). Important questions to be examined in the beverage industry include does price change cause the replacement of coffee and tea by soft drinks? If yes, by what percentage? Does this change similar in different seasons? This study investigates the main economic factors (prices and expenditures) and seasonal factors which change consumption patterns and interdependencies among the products using the data set obtained from ERS, USDA from 2004 to 2010 for non-alcoholic beverages.

The existing literature focuses on the demand analysis for non-alcoholic beverage separately for coffee, tea, milk, or other carbonated drinks separately or with a different product combination and most of the studies ignore the seasonal variables. Several past studies examined the demand for non-alcoholic beverages in different countries (Pofahl *et al.*, 2005; Yen *et al.*, 2004; Zheng and Kaiser, 2008). A recent study on the demand for non-alcoholic beverages in Japanese household show that temperature has significant impact on own price and cross price elasticities of the goods (Yohannes and Matsuda, 2015). Moreover, Arnade *et al.* (2004) argue that many factors such as advanced technology, storage facilities, low transportation cost can have high impact on seasonality which cause to have seasonal demand in domestic and international markets for non-alcoholic beverages. Thus, it is critical to account for seasonality in modeling demand for non-alcoholic products. Seasonality can be accounted for by including seasonal dummy variables like monthly or quarterly dummies in the model (Arande *et al.*, 2004) and since quarterly data are available, this study uses the latter approach.

The objectives of this study are to estimate the own and cross price elasticities for non-alcoholic beverages (NAB): non-diet carbonated beverages, diet carbonated beverages, non-carbonated caloric beverages, water, and unsweetened coffee and tea and to analyze seasonal demand for NAB. I also test for weak separability of NAB. It is very important to examine whether the non-alcoholic beverages are luxury, necessary or inferior goods. This study sheds light on elasticity and seasonal demand for non-alcoholic beverages in the United States and would be useful to beverage producers, policy makers, advertisers or promoters in designing marketing strategies.

Literature Review

The Almost Ideal Demand System (AIDS) model of Deaton and Muellbauer (1980) is one of the fundamental demand analysis models, which is useful in applied economics for analyzing consumer demand for many reasons. The AIDS model has considerable advantages over Rotterdam and Translog models. The AIDS model can be estimated using arbitrary first order approximation. Furthermore, it is simple to estimate because the non-linear price index can be approximated with the linear price index, which is econometrically easier than using the non-liner price index. The economic restrictions such as homogeneity and symmetry can be tested putting linear restrictions on parameters. Moreover, the AIDS model is derived from a specific cost function, which corresponds to a well-defined preference structure (Deaton and Muellbauer, 1980; Zheng and Kaiser, 2008).

Past studies on non-alcoholic beverage demand analysis mainly include these products: milk, juices, soft drinks, coffee and tea (Heien and Wessels, 1988; Kaiser and Reberte, 1996; Yen and Lin, 2001; Ueda and Frechette, 2002). Yen and Lin (2001) showed that child or adolescents increased consumption of soft drinks instead of milk as they became older using FIML and quasi-maximum likelihood (QML) methods. The results show that many factors such as income, gender, race, TV watching behavior affect the beverage consumption.

Many previous studies have used the AIDS model to estimate the demand for meat, alcoholic beverages and non-alcoholic beverages. For instance, Zheng and Kaiser (2008) used the AIDS model to estimate the impact of advertising on non-alcoholic beverages including bottle water and the results indicated that advertising increases the demand for fluid milks, soft drinks, and coffee and tea but no effects on juice and bottled water. Moosa and Baxter (2002) also used the AIDS model to examine the wine and beer consumption with seasonality and time trends. Including time trends and seasonality outperforms the regular AIDS model. This implies that the AIDS model for estimating demand for beverages consumption without seasonality variable may be biased. Similarly, Alamo and Malaga (2012) studied the demand for differentiated coffee at retail level in the United States using the AIDS model accounting for seasonality. The author found that differentiated coffees are complements for regular and unclassified coffee. Moreover, the results for expenditure elasticities showed that unclassified coffee is a luxury good while all coffee groups are normal goods.

Likewise, Yohannes and Matsuda (2015) examined the demand for non-alcoholic beverages for eight products (green tea, black tea, tea beverage, coffee, coffee beverage, fruit and vegetable juice, carbonated beverages, and milk) in Japan using the linear approximation quadratic Almost Ideal Demand System model. Based on the expenditure elasticity, the authors found that green tea, black tea, coffee, and fruit and juice are luxury goods whereas carbonated beverages and milk are necessary goods in the Japanese households. In addition, temperature has significant impact on the demand for these products. They accounted for seasonality using monthly dummy variables. This indicates that seasonality should be accounted for in demand analysis for non-alcoholic beverages. However, the study did not disaggregate carbonated beverages. Aggregation over many products may lose significant information about consumer behavior.

One of the issues on estimating the demand for many products from market level data is the problem of dimensionality (i.e. the number of parameters to be estimated increases exponentially). The problem of dimensionality can be reduced by aggregating products to smaller groups. The problem of dimensionality may still exist, however, the AIDS model has been widely accepted and used for modeling consumer demand. Thus, an important point to be noted here is that a modeler should aggregate products without sacrificing important information based on data availability.

Research Methods

The AIDS model consists of a demand system, which include a group of demand equations. In the AIDS model, a system of equations can be estimated simultaneously. This study uses the first difference version of the AIDS model, which was estimated using the Iterative Seemingly Unrelated Regressions (ITSUR) method. The ITSUR method accounts for correlation across equations. Since the sum of the expenditure share is equal to one in the expenditure share equations, one of the share equations should be deleted during estimation to avoid singularity in the variance-covariance matrix. The budget share equation for unsweetened coffee and tea was dropped from this estimation process and the coefficients for the coffee and tea equation are recovered based on the theoretical assumption. Note that any expenditure share equation can be dropped because whichever equation is deleted during the estimation process does not affect the results (Goodwin, 2008). Homogeneity and symmetry restrictions are imposed during the model estimation.

The ITSUR method is also not free from criticism. For example, the ITSUR method may not be maximum likelihood in the presence of autocorrelation (Seale, Marchang and Basso, 2003). Autocorrelation could exist in quarterly data, but to check the robustness of the results, the Full Information Maximum Likelihood (FIML) method is also employed. The FIML method also provides a similar and consistent result as ITSUR. It indicates that the first difference of data removes the first order autocorrelation if there were an issue of first order autocorrelation. Therefore, this study only reports parameters estimates obtained from the ITSUR method. The FIML estimates can be obtained from the author upon request.

To capture the effect of seasonality, quarterly seasonal dummy variables (winter, spring, summer, and fall seasons) are included in the standard AIDS model. Thus, the expenditure share equation, which is a function of prices and associated expenditure to be estimated for the first difference version of AIDS model including seasonal variables is given as follows:

$$w_i = \alpha_i + \sum_j \gamma_{ij} lnp_j + \beta_i \ln(X/P) + \sum_{j=1}^{3} d_{ij} D_j \qquad (1)$$

Where, $i = 1, 2, \ldots\ldots 5$ indexes of non-diet, diet, caloric, water, and coffee and tea beverages, respectively, $X = \sum p_i q_i$ is the total expenditure on five goods in the system, p_i and p_j are the retail price of non-diet, diet, caloric, water, and coffee and tea beverages, q_i is the quantity demanded for good i, $w_i = \frac{p_i q_i}{X}$ is the expenditure share on good i, α_i is the constant coefficient of the expenditure share equation for good i, γ_{ij} is the slope coefficient for each equation associated with product i, β_i represents the expenditure elasticity, d_{ij} is the coefficient of seasonal dummy (D_j) for each product with each share equation, and P is a non-linear price index which is given as follows:

$$\ln P = \alpha_0 + \sum \alpha_i \, lnp_i + 1/2 \sum_i \sum_j \gamma_{ij} lnp_i lnp_j \qquad (2)$$

The system of equations as given by (Eqn. 1) is non-linear due to the non-linear price index. The non-linear AIDS model can be transformed into a linear one with a linear approximation of non-linear price index as suggested by Deaton and Muellbauer (1980). The linear price index can be expressed as:

$$\ln P = \sum_i^n w_i \, lnp_i \qquad (3)$$

With a linear approximation of the non-linear price index, the AIDS model is linear in the parameters and can be nicely approximated (Deaton and Muellbauer, 1980). This study uses the linear price index which is easier than (Eqn. 2) and still gives a good approximation of the non-linear price index. It is assumed that budget shares have a deterministic trend and seasonality. This implies that a model with a constant intercept; a time trend and correctly specified deterministic seasonal dummies. For example, Arnade and Pick (1998) and Alston *et al.* (1998) used deterministic trends and seasonal dummies in demand estimation. This paper also employs a similar approach regarding seasonality.

The adding-up assumption requires $\sum_i \alpha_i = 1, \sum_i \gamma_{ij} = 0$, $\sum_i \beta_i = 0$, and $\sum_i dij = 0$ (4)

This assumption satisfies automatically if data adds up requiring the sum of the share of expenditure on each product is equal to the total expenditure (i.e. $\sum_i^n w_i = 1$). Thus, adding additional variables like seasonal dummies in the budget share equations do not affect the adding up assumption. Moreover, the assumptions of homogeneity and symmetry are imposed during the AIDS model estimation. The demand function is the homogeneous of degree one in prices and expenditures, which implies that when price and expenditure are multiplied by a constant factor (say t), the quantity demanded remains the same. It means there is no money illusion. Similarly, symmetry indicates that cross price effects for the Hicksian demand are equal (Deaton and Muellbauer, 1980).

Homogeneity requires: $\sum_i \gamma_{ij} = 0$ for all i (5)

Symmetry requires: $\gamma_{ij} = \gamma_{ij}$ $for\ all\ i \neq j$ (6)

In general, price shows an increasing trend over time. Thus, it is important to account for the trend in modeling consumer demand. Since the first difference AIDS model accounts for this trend, there is no reason to use a time trend variable in the model. Bryant and Davis (2008) argued that the first difference AIDS (FD-AIDS) model gives better estimates than the level AIDS model.

The first difference version of the AIDS model is given below:

$\Delta w_i = \sum_j \gamma_{ij} \Delta lnp_j + \beta_i \Delta \ln(X/P) + \sum_{j=1}^{3} dij \, \Delta D_j$ for all i. (7)

In (Eqn. 1), β_i stands for the expenditure elasticity, which indicates whether a good i is luxury or necessities. If $\beta_i > 0$, then a good i is luxury and if $\beta_i < 0$, then a good i is necessary. Although, β_i also represents for expenditure elasticity, the following formula given by (Eqn. 8) is widely used for calculating expenditure elasticity.

The following formulas for computing elasticity are based on Barten (1969). The expenditure elasticity for good i can be expressed as follows:

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

The uncompensated (Marshallian) price elasticity for a good i is:

$$e_{ij} = -\delta_{ij} + (\gamma_{ij} - \beta_i w_j)/w_i \qquad (9)$$

where $\delta_{ij} = 1$ if $i = j$ and $\delta_{ij} = 0$ if $i \neq j$.

Similarly, the compensated (Hicksian) price elasticity can be expressed as follows:

$$e*_{ij} = -\delta_{ij} + \frac{\gamma_{ij}}{w_i} + w_j \qquad (10)$$

It is important to note that the calculation of the elasticities from the AIDS model are based on the Marshallian (uncompensated) demand. In the Marshallian demand, both income effect and substitution effect are considered assuming income and all other prices are constant. The utility level may change but the income is constant in the Marshallian demand. However, in the compensated demand, the income effect is not considered so that only the substitution effect is accounted for. In other words, consumers are compensated for the price rise through the increase of income as the consumers get the same level of utility even after the price increase (Mas-Colell *et al.,* 1995).

Data and Empirical Results

This section discusses data and descriptive statistics of variables and estimated parameters of the first difference AIDS model and the model was estimated by using the SAS statistical package. Quarterly market level panel data for each product covering from 2004 to 2010 are obtained from Economic Research Service, United States Department of Agriculture (ERS, USDA). Interesting feature of this data set is that quantity is not directly available. Instead, quantity is obtained dividing expenditures by the price of a purchased good. This research includes five non-alcoholic beverages: non-diet carbonated beverages, diet carbonated beverages, non-carbonated caloric beverages, water, and unsweetened coffee and tea.

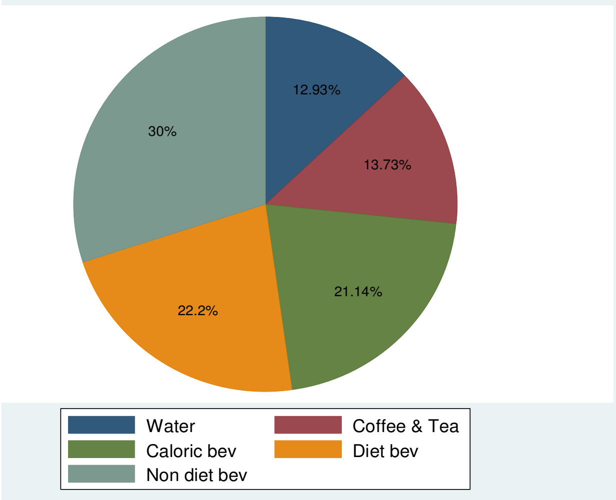

Fig. 1: Budget share of non- alcoholic beverage consumption in the United States

Fig. 1 depicts that the share of expenditure from 2004 to 2010 on non-alcoholic beverages. The non-diet expenditure share accounts for the largest percentage (30%) of the total expenditure. The expenditure share on carbonated beverages is approximately 52% (non-diet beverages (30%) and diet (22.2 %)) of the total budget. The remaining 48% of the total budget is shared among other beverages (caloric beverages (21.14 %), coffee and tea (13.73%), and water (12.93 %)).

Fig. 2 exhibits the inverse relation between price and quantity for non-diet carbonated beverages from 2004 to 2010. There is a large increase in quantity in 2005. This graph clearly shows the seasonality and time trend (price has an upward trend whereas quantity has a downward trend) for both price and quantity.

Fig. 2: Price and quantity demanded for non-diet carbonated beverages in the United States

Fig. 3 demonstrates that the first difference method removed the trend in both variables. The time trend is removed after the first difference, but seasonality still exists indicating its importance in the model. The above graphs are only for the market level one (Hartford) and non-diet product. The remaining market levels and other products also exhibit similar patterns in prices and quantities. Thus, to save space, graphs for other products are not reported here.

Table 1 reports the summary statistics of prices and quantities purchased for the five non-alcoholic beverages. On average, the caloric beverage is the most expensive one ($4.82 per gallon) whereas coffee and tea was the cheapest product ($ 2.62 per gallon); even more so than water. The non-diet good has the largest quantity demanded whereas water has the smallest quantity demanded.

Table 2 summarizes the estimates for the FD-AIDS model using the ITSUR method. The coefficient for non-diet (b1) is positive (0.019) which is significant at 1% level indicating it is a luxury good. Caloric beverages (b3) and coffee and tea (b5) have significant negative coefficients, which imply that they are necessary goods. The coefficients for diet and water are not significant. The estimates from Table 1 is used to calculate expenditure, Marshallian and Hicksian elasticities.

The slope coefficient for non-diet (g11) and water (g44) have negative signs indicating corresponding own price increases when the demand for the product decreases. These estimates are consistent with economic theory. But the coefficient for diet carbonated good (g22), and coffee and tea (g55) have a positive value seems implausible. One possible reason for it is that the expenditure share is regressed on price; not a direct relation between price and quantity. If the price decreases, the expenditure share on a specific good should decrease.

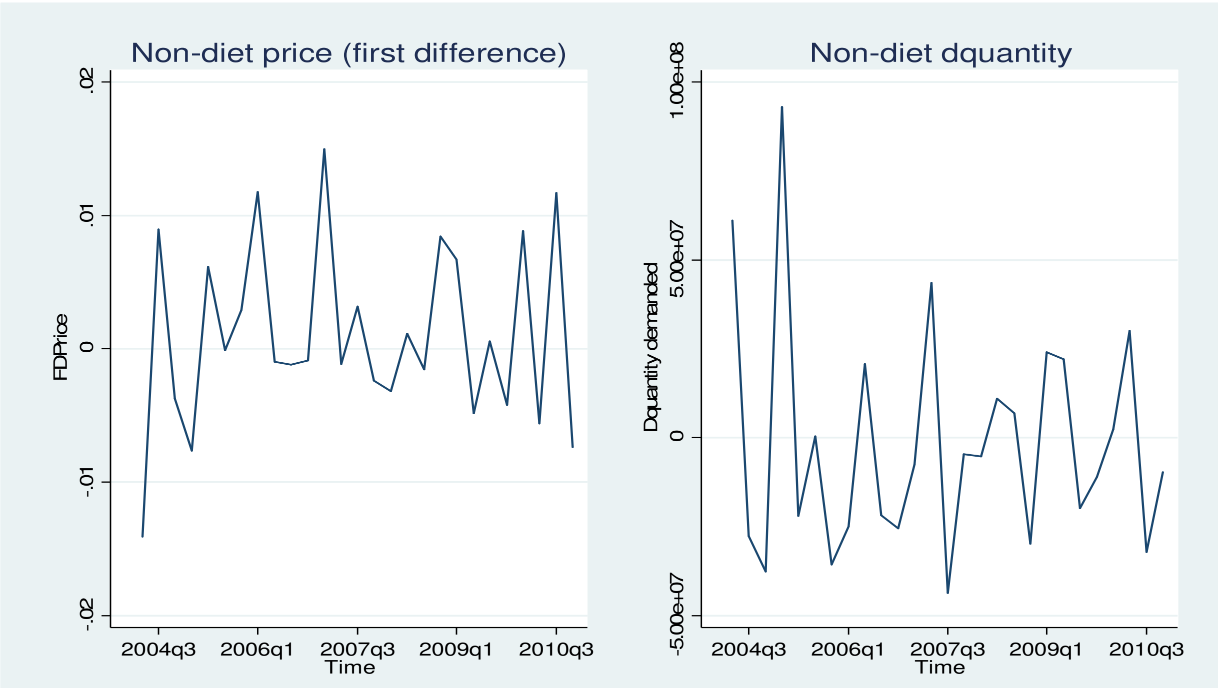

Fig. 3: Price of non-diet carbonated beverages after first difference

Table 1: Summary statistics for prices and quantities of non-alcoholic beverages

Products	Mean	Std. deviation	Minimum	Maximum
Price of non-diet (p_1)	3.995	0.542	2.824	5.674
Price of Diet (p_2)	3.639	0.388	2.753	4.828
Price of Caloric bev (p_3)	4.815	0.590	3.304	7.303
Price of Water (p_4)	3.132	0.418	2.013	5.559
Price of Coff and tea (p_5)	2.621	0.326	1.802	3.797
Quantity of Non diet (q_1)	1.40E+07	7.20E+06	2.29E+06	3.43E+07
Quantity Diet (q_2)	1.12E+07	5.77E+06	2.57E+06	2.79E+07
Quantity Caloric bev (q_3)	8.15E+06	4.22E+06	1.41E+06	2.50E+07
Quantity Water (q_4)	7.72E+06	4.70E+06	8.69E+05	3.11E+07
Quantity Coff and tea (q_5)	9.63E+06	4.36E+06	1.99E+06	2.01E+07

* Price is measured in the US dollar per gallon (3.78 liters) whereas quantity is measured in gallon.

Table 2: Estimated parameters and associated standard errors for the first difference AIDS model.

Parameter	Estimate	Std Error	t Value	Pr > |t|
b1*	0.0189	0.0043	4.3900	<.0001
b2	-0.0005	0.0033	-0.1500	0.8770
b3	-0.0058	0.0033	-1.7900	0.0738
b4	-0.0011	0.0028	-0.3900	0.6939
b5	-0.0114	0.0027	-4.2800	<.0001
g11	-0.0515	0.0124	-4.1600	<.0001
g12	-0.0006	0.0080	-0.0800	0.9380
g13	0.0031	0.0065	0.4800	0.6321
g14	0.0447	0.0060	7.3900	<.0001
g15	0.0044	0.0068	0.6400	0.5228
g22	0.0295	0.0090	3.2800	0.0011
g23	-0.0049	0.0054	-0.9000	0.3703
g24	-0.0120	0.0049	-2.4800	0.0134
g25	-0.0120	0.0057	-2.1100	0.0354
g33	0.0282	0.0062	4.5200	<.0001
g34	-0.0106	0.0041	-2.6100	0.0091
g35	-0.0158	0.0044	-3.5600	0.0004
g44	-0.0093	0.0052	-1.7900	0.0740
g45	-0.0127	0.0042	-3.0300	0.0025
g55	0.0362	0.0069	5.2200	<.0001
d11	-0.0069	0.0012	-5.6300	<.0001
d12	-0.0081	0.0016	-4.9700	<.0001
d13	-0.0158	0.0015	-10.8800	<.0001
d21	0.0001	0.0009	0.0600	0.9490
d22	-0.0032	0.0013	-2.5300	0.0116
d23	-0.0106	0.0011	-9.6400	<.0001
d31	0.0118	0.0009	12.8600	<.0001
d32	0.0299	0.0012	24.2000	<.0001
d33	0.0367	0.0011	33.8500	<.0001
d41	0.0122	0.0008	15.3400	<.0001
d42	0.0205	0.0011	19.3800	<.0001
d43	0.0272	0.0009	29.4500	<.0001

*Good 1 (non-diet), good 2 (diet), good 3 (caloric beverage), good 4 (water), and good 5 (coffee and tea). b1 and b2 represents the coefficients for non-diet and diet, respectively, and so on. Similarly, for seasonal dummy variables, d11, d21, and d31 represent for non-diet, diet, and caloric beverage for the first quarter, respectively and so on.

Regarding the seasonal variables coefficients, caloric beverages and water have positive coefficients indicating that higher budget shares are coupled with first, second, and third quarter compared to the fourth quarter. Similarly, for non-diet beverages, the expenditure share decreases in the first, second, and third quarter compared to the fourth quarter. These estimates are highly significant. However, we are more interested in calculating expenditure elasticity and price elasticity using these estimates from Table 2, which are reported in Table 3, 4, and 5.

Elasticity Estimates

The expenditure, uncompensated, and compensated elasticities were calculated and reported for all non-alcoholic beverages in Table 3, 4, and 5, respectively.

Table 3: Expenditure elasticity for all non-alcoholic beverages

Products	Elasticity
Non-diet bev.	1.632
Diet bev.	0.9977
Caloric bev.	0.9725
Water	0.9913
Coff and tea	0.9188

All the elasticities (expenditure, compensated, and uncompensated) are estimated at the mean value for the respective products.

Expenditure elasticity shows the percentage change in the consumption of non-alcoholic beverages for a percentage change in expenditure for every product. Table 3 depicts that the expenditure elasticity for non-diet is 1.63 (greater than 1), which indicates that non-diet is a luxury good. It means non-diet goods are more price sensitive than other products. A 1% increase on the expenditure of the non-diet beverages would approximately increase the quantity demanded by 1.63%. This result is consistent with the past literature (Dharmasena and Caps 2009; Zheng and Kaiser 2008; Alviloa *et al.*, 2010). Remaining products have expenditure elasticity less than 1 (approximately close to 1). It indicates that a 1% increase in expenditure on these goods would approximately increase the quantity demanded by 1%. The expenditure elasticity of less than 1 implies that these non-alcoholic beverages are necessary goods. For example, coffee and tea is considered as a necessary good, which seems reasonable because if people are consuming it for a long time, it is likely they will consume it in future as well even if the price increases significantly because it has some addictive characteristics. This result for coffee and tea as a necessary good is also in the same line with some of the previous works including Dharmasena and Caps (2009) and Alviloa *et al.* (2010). However, this result contradicts the conclusion of Yen *et al.* (2004) who found coffee and tea as a luxury good (expenditure elasticity is 1.13). Zheng and Kaiser (2008) found that bottled water is the most price elastic good in non-alcoholic beverages groups. In this research, data are not available for bottle water (data is only available for aggregate level water). In aggregate, the expenditure elasticity for water is about one.

Table 4: Marshallian elasticity matrix for non-alcoholic beverages

Products	**Non-diet**	**Diet**	**Caloric**	**Water**	**Coff and tea**
Non-diet	-1.191	-0.021	-0.008	0.131	-0.004
Diet	-0.002	-0.866	-0.021	-0.054	-0.054
Caloric	0.021	-0.017	-0.861	-0.044	-0.069
Water	0.351	-0.093	-0.082	-1.072	-0.098
Coff and tea	0.042	-0.074	-0.101	-0.079	-0.732

Table 4 reports that all uncompensated own price elasticities have a negative sign which is consistent with microeconomic theory of a downward slope demand curve. The Marshallian (uncompensated) cross price elasticity for non-diet and diet; non-diet and caloric beverages; and non-diet and coffee and tea have negative signs, which indicates that these pairwise products are complementary. Similarly, the cross price-elasticity for non-diet and water is positive, which implies that water is a substitute for non-diet. The cross price elasticities for caloric beverage and coffee and tea are not symmetric in sign whereas the rest of the products are symmetric in sign.

Table 5 reports that all Hicksian (compensated) own price elasticities have negative signs as expected. All the compensated cross price elasticities are positive which implies that the set of non-alcoholic beverages are net substitutes indicating if the price of one good (say, non-diet) from a set of non- alcoholic beverages increases, it will increase the demand for other goods (remaining goods) keeping other things constant. The major substitutes for the non-diet product are diet, caloric beverages and water. This is consistent with the result of Alviola *et al.* (2010). Similarly, the major substitutes for coffee and tea are non-diet and diet beverages

Table 5: Hicksian elasticity matrix for non-alcoholic beverages

Products	**Non-diet**	**Diet**	**Caloric**	**Water**	**Coff and tea**
Non-diet	-0.874	0.214	0.216	0.266	0.146
Diet	0.296	-0.645	0.189	0.074	0.087
Caloric	0.311	0.198	-0.655	0.080	0.068
Water	0.647	0.126	0.128	-0.945	0.041
Coff and tea	0.317	0.129	0.093	0.039	-0.602

Test for Weak Separability

The weakly separable preference is a flexible assumption on the consumer preference separability. This assumption indicates that products can be classified into groups so that preferences within groups are independent of the quantity demanded in other groups (Deaton and Muellbaur, 1981). To test weak separabilty, five food products are divided into the three groups based on their characteristics: non-diet carbonated beverages (good 1) and diet carbonated beverages (good 2) into the first group. Similarly, caloric beverages (good 3) and water (good 4) into the second group and unsweetened coffee and tea (good 5) into the third group. The products are rearranged in different groups, but the conclusion about weak separability still remains the same.

The regular Wald test and adjusted Wald test are used to test weak separability following the similar approach of Eales and Unnevehr (1988).

The parameters restrictions for the AIDS:

$$\gamma_{ik}(\beta_j + w_j) - \gamma_{jk}(\beta_j + w_i) + (w_i\beta_j - w_j\beta_i)(w_k - \beta_k \ln(X/P)) = 0 \quad (11)$$

Where, i = 1, k = 3, and j = 2 for the hypothesis 1 (H_{01}) and so on.

There are five null hypotheses that need to be tested corresponding to five non- redundant restrictions to be tested: (1) good 1 and good 2 are weakly separable from good 3; (2) good 1 and good 2 are weakly separable from good 4; (3) good 1 and good 2 are weakly separable from good 5; (4) good 3 and good 4 are weakly separable from good 1; (5) good 3 and good 4 are weakly separable from good 5.

H_{01}: $g_{13}(b_2+w_2) - g_{23}(b_1 + w_1) + (w_1b_2 - w_2b_1)(w_3 - b_3 * \ln(x/p)) = 0$

H_{02}: $g_{14}(b_2+w_2) - g_{24}(b_1 + w_1) + (w_1b_2 - w_2b_1)(w_4 - b_4 * \ln(x/p)) = 0$

H_{03}: $g_{15}(b_2+w_2) - g_{25}(b_1+w_1) + (w_1b_2-w_2b_1)(w_5-b_5 * \ln(x/p)) = 0$

H_{04}: $g_{13} (b_4+w_4) - g_{14} (b_3+w_3) + (w_3b_4-w_4b_3) (w_1-b_1*\ln(x/p)) = 0$

H_{05}: $g_{35} (b_4+w_4) - g_{45} (b_3+w_3) + (w_3b_4-w_4b_3) (w_5-b_5*\ln(x/p)) = 0$

The Wald test for weakly separability is reported as below: The results for the regular Wald statistic is 54.79, which is significant at 1% level. The adjusted Wald test statistics is additionally calculated as follows:

$$W^* = Adj\ W = \frac{W/q}{MT/(MT-k)} \quad (12)$$

$$= \frac{54.79/5}{4*979/(4*979-14)} = 10.91$$

Where, W = regular Wald test, q = number of restrictions in the test, M is the number of equations, T is the number of observations, and k is number of parameters to be freely estimated (number of parameters minus the number of restrictions).

The critical value of F- statistics is approximately 2.7 for 5 restrictions and 972 degrees of freedom. Thus, based on these results, we do reject the null hypothesis of weak separability. This implies that the goods are not weakly separable. This shows that consumers are not consistent in their choice of non-alcoholic beverages and consumers may like to drink different products at different times. They do not prefer consistently one group of products over any other group of products. The result is intuitive because, in general, people like to enjoy different products.

Conclusion

The first difference version of the AIDS model was used to estimate the demand for non-diet carbonated beverages, diet carbonated beverages, non-carbonated caloric beverages, water, and unsweetened coffee and tea in the United States using the ITSUR and FIML methods. The expenditure, own, and cross price elasticities for all five products were estimated accounting for seasonality. The results show that non-diet beverages have significant positive coefficients in demand estimation, which imply that non-diet beverages are normal goods. Caloric beverages and coffee and tea have significant negative coefficients which indicate that these are necessary goods. The coefficients for diet and water are statistically insignificant. The expenditure elasticity for non-diet beverages was higher than one indicating that non-diet beverages are luxury goods and the remaining goods have the expenditure elasticity less than one indicating they are necessary goods. The uncompensated and compensated own price elasticities for all products are negative, consistent with microeconomic theory of a downward slope demand curve. In addition, these products are not weakly separable based on the regular Wald test and adjusted Wald test.

This research uses the market level data and some of results contradict with economic theory such as positive own price elasticity based on the AIDS model. Some of possible reasons for conflicting outcomes might be that theory based on individual consumer but we do not have data for individual consumer. It may be the case that the individual consumer decisions are not represented in market level data. However, most of the estimates are consistent with economic theory. These results would be useful for consumers, policy makers, retailers and manufacturers in designing marketing strategies.

It is assumed that new research and information showing the relationship between consumption of goods and health have impacts on the demand for goods. For example, research including health information indices as an explanatory variable in the model have some short term impacts in the beef industry of the United States (Tonser *et al.*, 2010). Similarly, a more recent study shows that regular consumption of coffee and tea could reduce the type 2 diabetes risks by 11% (Bhupathiraju *et al.*, 2014). Incorporating this kind of health variable (index) in the model would worthy of future research and future study of convenience demand and food away from home decisions could provide valuable insight in a non-alcoholic beverages demand analysis.

Acknowledgement: This material is based upon work supported by National Science Foundation Grant: From Crops to Commuting: Integrating the Social, Technological, and Agricultural Aspects of Renewable and Sustainable Biorefining (I-STAR); NSF Award No.: DGE-0903701.

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