Demand for Organic /Non-Organic Non-alcoholic Beverages in the United States: Application of Semiparametric Estimation of Censored Quadratic Almost Ideal Demand System (C-QUAIDS) with Household-Level Micro Data

Senarath Dharmasena
Department of Agricultural Economics
Texas A&M University
sdharmasena@tamu.edu

Oral Capps, Jr.
Department of Agricultural Economics
Texas A&M University
ocapps@tamu.edu

Selected Paper prepared for presentation at the Agricultural and Applied Economics Association's 2014 AAEA Annual Meetings, Minneapolis, MN, July 27-29, 2014

Demand for Organic /Non-Organic Non-alcoholic Beverages in the United States: Application of Semiparametric Estimation of Censored Quadratic Almost Ideal Demand System (C-QUAIDS) with Household-Level Micro Data

Senarath Dharmasena and Oral Capps, Jr.

Background

There are many different types of nonalcoholic beverages available in the United States today compared to decade ago. Functionality and health dimensions of beverages have changed over the years. On top of conventional hydration and refreshment functions, beverages now are fortified with numerous vitamins, minerals, proteins, antioxidants, favorable fatty acids, etc (BMC, 2010; 2011, 2012, 2013). Organically produced nonalcoholic beverages are another burgeoning segment of beverage marketplace that competes with their conventional (or nonorganic) counterparts (BMC, 2013). For example, U.S. retail sales of organic milk have been growing since mid 1990s and as of 2005 organic milk and cream sales were $1 billion (USDA-ERS, 2007). Organic milk and cream made up of 6% of retail milk sales as of year 2007 (USDA-ERS, 2007). Currently, in addition to organic milk, we find host of other organic beverages in the market, such as organic fruit beverages, organic dairy alternative beverages, organic tea and coffee, organic carbonated soft drinks and organic alcoholic beverages (BMC, 2013).

The extant literature mostly centered attention to investigating demand for organic milk. For example Alviola and Capps (2010) estimated demand for organic and conventional fluid milk in the United States through Heckman two-step procedure to uncover own-price, cross-price and income elasticities and purchase responses of selected demographic variables associated with organic milk. Chang *et al*., (2011) used weekly milk scanner data from six stores of national supermarket chain located in central Ohio to empirically estimate purchase patterns of suburban and inner-city residents for conventional and organic milk. Auction experiments were used by Bernard and Bernard (2009) to examine demand relationships and willingness to pay for organic and conventional milk. Additionally, Zheng *et al.*, (2011) centered attention on investigating consumer preferences for attributes of organically produced soymilk.

Therefore, it is clear that demand interrelationships and demographic profiles for other organic beverages, such as organic fruit beverages, organic dairy alternative beverages, organic tea and coffee, organic carbonated soft drinks and organic alcoholic beverages are yet to be uncovered, hence worth exploring. This knowledge of price sensitivity, substitutes and complements and demographic profiling in particular is important for manufacturers, retailers and advertisers of these beverages from a competitive intelligence standpoint and making strategic decisions.

In this censored demand system analysis, we use expenditure, quantity and demographic information obtained from 2012 Nielsen Homescan scanner panel. Novelty also spans across the application of semiparametric estimation procedure suggested by Sam and Zheng (2010) in estimating censored quadratic almost ideal demand system (C-QUAIDS) with household-level micro data. The general objective of this study is to determine demand interrelationships between organic and non-organic beverages using C-QUAIDS estimated using semiparametric procedure suggested by Sam and Zheng (2010). Specific objectives are to: (1) estimate compensated and uncompensated own-price and cross-price elasticities, and expenditure elasticities for organic beverages and their non-organic counterparts; (2) determine demographic factors affecting the purchase of organic and non-organic beverages; and (3) shed light on the use of semi--parametric procedures to estimate consumer demand with micro data, showing non-normal error distributions of censored decision equations.

Data and Methodology

We use quantity, expenditure and household demographic characteristics with respect to purchase of selected set of organic and non-organic beverages obtained from 2012 Nielsen Homescan scanner panel. This panel consists of approximately 60,000 representative households from across the United States.

Selected beverages are organic and non-organic carbonated soft drinks, organic and non-organic milk, organic and non-organic fruit beverages, organic and non-organic tea and coffee, organic and non-organic dairy alternative beverages like soymilk.

The paper uses a two-step semi-parametric approach suggested by Sam and Zheng (2010) for the estimation of censored demand system. This is exempt from distributional misspecification (does not assume a normally distributed error in the first-stage equation) and accommodates a certain form of heteroskedasticity. We use the Klein and Spady (1993) semi-parametric single-index model instead of the conventional probit model used in alternative two-step estimators such as Shonkwiler and Yen (1999) in the first-stage equation to model the decision to purchase any beverage. The advantage of the Klein and Spady (1993) model is that, without relying on distributional assumptions, this method generates consistent and efficient estimates and furthermore accommodates heteroskedasticity of a certain form in the error term. In the second stage, the QUAIDS (Banks *et al*, 1997) is used to model the conditional demand for organic and non-organic non-alcoholic beverages.

Methodology explained below is from Sam and Zheng (2010). For *n* goods and *j* (cross-sectional) observations, binary (0-1) (d_{ij}) indicator function *I* can be expressed as follows:

(1) $$d_{ij} = I(W_{ij}^{'}\gamma_i + v_{ij})$$

where $W_{ij}^{'}$ is vector of regressors, γ_i is model parameter and v_{ij} is zero mean and finite variance error process. The conditional response variable, Y_{ij} in the second-stage equation is as follows:

(2) $$Y_{ij} = d_{ij} * (g(X_{ij}, \beta_i) + \epsilon_{ij})$$

where X_{ij} is vector of regressors, β_i is model parameter and ϵ_{ij} is zero mean and finite variance error. Given equations (1) and (2), the conditional mean can be expressed as follows:

(3) $$E(Y_{ij}|X_{ij}, W_{ij}) = E(Y_{ij}|X_{ij}, W_{ij}; d_{ij} = 1) * prob(d_{ij} = 1).$$

The unknown cumulative distribution function of the error term v_{ij} is denoted by $F_i(W_{ij}^{'}\gamma_i)$. Then we can write the system of equations of interest as follows:

$$(4) \qquad Y_{ij} = \left(g(X_{ij}, \beta_i) + \lambda_i(W_{ij}^{'}\gamma_i)\right) * F_i(W_{ij}^{'}\gamma_i) + \eta_{ij}.$$

The parameters of the first step are estimated using Klein and Spady (1993) semiparametric single-index model. The second stage conditional demand system (the QUAIDS model) can be expressed as follows: w_i is the budget share of dairy product; $a(P)$ is the Translog price index; $b(P)$ is the Cobb-Douglas price index; m is total expenditure; p is price of dairy product:

$$(5) \qquad w_i = \left(\alpha_i + \beta_i \left(ln\frac{m}{a(P)}\right) + \sum_{k=1}^{n} \gamma_{ik} lnp_k + \sum_{l=1}^{L} \tau_{il} \left(W_i^{'}\hat{\gamma}_i\right)^{l-1} + \frac{\lambda}{b(P)}\left(ln\frac{x}{a(P)}\right)^2\right) * \hat{F}_i(W_i^{'}\hat{\gamma}_i)$$

Expected Results and Discussion

Preliminary analysis was performed using 2008 Nielsen Homescan data comprised of 61,440 households. For this preliminary analysis we estimated demand for fruit beverages, milk and carbonated soft drinks (both organic and non-organic versions) as single equation models and used a Heckman two-step estimator (Heien and Wessells 1990) to account for censoring in the data. Market penetration for organic fruit beverages, organic carbonated soft drinks, and organic milk was respectively 5.59%, 1%, and 7.25%. High income, more educated (some college and post-college) households purchased more organic carbonated soft drinks, organic fruit beverages and organic milk. Estimated own-price elasticity of demand for organic fruit beverages was -0.67 while its non-organic counterpart's own-price elasticity of demand was estimated to be -0.60. Non-organic carbonated soft drinks own-price elasticity of demand was estimated to be -0.89 while its organic counterpart was -0.32. Through this study, with the estimation of demand system, we are in position to obtain own-price, cross-price and expenditure elasticities with respect to organic and nonorganic nonalcoholic beverages considered. Finally, we will be able to test for normality of the errors of each binary censored equation using Horrowitz and Hardle (1994) to lend support the use of semi-parametric approach in estimating C-QUAIDS.

References

Alviola IV, P.A., and O.Capps, Jr. 2010 "Household Demand Analysis or Organic and Conventional Fluid Milk in the United States Based on the 2004 Nielsen Homescan Panel." *Agribusiness*, 26(3):369-388

Banks, J., R. Blundell, and A. Lewbel, 1997, "Quadratic Engle Curves and Consumer Demand." *The Review of Economics and Statistics*, 79(4):527-539

Bernard, J.C., and D. J. Bernard, 2009, "What is it About Organic Milk? An Experimental Analysis." *American Journal of Agricultural Economics,* 91(3):826-836

BMC, 2010, 2011, 2012, 2013, Beverage Marketing Corporation Multiple Beverage Marketplace Reports

Chang, C-H., N.H.Hooker, E. Jones, A. Sam, 2011 "Organic and Conventional Milk Purchase Behaviors in Central Ohio." *Agribusiness*, 27(3):311-326

Heien, D.M. and C.R. Wessells, 1990, "Demand Systems estimation with Microdata: A Censored Regression Approach." Journal of Business and Economic Statistics 8(3): 365-371.

Horowitz, J.L., and W. Hardle, 1994, "Testing A Parametric Model against a Semiparametric Alternative." *Economic Theory,* 10:821-48

Klein, R. L., and R.H. Spady, 1993, "An Efficient Semiparametric Estimator for Binary Response Models." *Econometrica*, 61:387-421

Sam, A. G., and Y. Zheng, 2010, "Semiparametric Estimation of Consumer Demand Systems with Micro Data." "*American Journal of Agricultural Economics,* 92(1):246-257

Shonkwiler, J.S., and S.T. Yen, 1999, "Two-Step Estimation of a Censored System of Equations." *American Journal of Agricultural Economics,* 81:972-82

USDA-Economic Research Service, 2007, Retail and Consumer Aspects of the Organic Milk Market, LDP-M-155-01

Zheng, Y., H.H. Peterson, and X. Li, 2011, "Consumer Preferences for Attributes of Organic Processed Foods: The Case of Soymilk in the United States." Poster presented at the Agricultural and Applied Economics Association Annual Meetings, Pittsburgh, PA