# Model Specification Uncertainty and Tax on Sugar-Sweetened Beverages: Bayesian Averaging of Classical Estimates Approach

**Senarath Dharmasena***
**Henry L. Bryant****

*Agribusiness, Food and Consumer Economics Research Center (AFCERC)
**The Agricultural and Food Policy Center (AFPC)
Department of Agricultural Economics
Texas A&M University
College Station
TX 77843-2124
USA
Email: sdharmasena@tamu.edu
Email: h-bryant@tamu.edu

***Selected Poster prepared for presentation at the Agricultural and Applied Economics Association (AAEA) Annual Meeting, Washington DC, August 4-6, 2013***

# Model Specification Uncertainty and Tax on Sugar-Sweetened Beverages: Bayesian Averaging of Classical Estimates Approach

Senarath Dharmasena and Henry L. Bryant
Department of Agricultural Economics, Texas A&M University, USA

## Background

The non-alcoholic beverage market in the U.S. currently is a multi-billion dollar industry growing steadily over the past three decades (American Beverage Association, 2011). A notable body of research argues that obesity rates in the United States are coupled with increased intake of calories through the consumption sugar-sweetened non-alcoholic beverages (Vartanian *et al*., 2007; Malik *et al*., 2006; Pereira, 2006). This obesity crisis in the United States is generating alternative policy options for combating the problem. One alternative widely proposed is a tax on sugar-sweetened non-alcoholic beverages. First step to analyzing the effect of such taxes on the intake of calories is to generate reliable own-price and cross-price elasticity estimates with respect to a set of non-alcoholic beverages. These elasticity estimates generally depend on model parameters and variables, and as a result they can vary by model specifications as well as evaluation points. That being said, model specification uncertainty has a direct link to uncertainty in elasticity estimates, hence calculated policy variables such as change in calories as a result of tax on sugar-sweetened beverages.

Although, several studies pertaining to demand for non-alcoholic beverages have been conducted in the past three decades, only very few have centered attention to taxing sugar-sweetened beverages and its consequences on caloric intake derived from consumption of sugar-sweetened beverages (Fletcher et al., 2010; Zhen et al., 2011; Smith et al., 2010 and Dharmasena and Capps, 2012). Furthermore, model specification uncertainty is still a concern, hence uncertainty in elasticity estimates and changes in calories. Numerous model specification issues have been studied in the past literature: *functional form, single equations and demand systems.*

So far all articles have used classical pair-wise testing procedures to explore the model space taking few assumptions or dimensions at a time. However, these procedures are not adequate for exploring multiple dimensions, hence the need for more refined approach. That being said, the purpose of this paper is to estimate U.S. demand for non-alcoholic beverages using Bayesian Averaging of Classical Estimates approach recently developed by Sala-i-martin, Doppelhofer, and Miller (2004) and an extension of the same to handle systems of equations by Bryant and Davis (2008) to shed light on model and elasticity uncertainty issues, and consequently changes in caloric intake as a result of tax on sugar-sweetened beverages. This approach has the advantage of exploring a large model space.

In this paper, we will consider three major model dimensions commonly faced by an applied demand analyst, specifically centering attention to U.S. consumption of non-alcoholic beverages. Model dimensions considered are; functional form, imposition of theoretical restrictions (homogeneity, symmetry and adding-up), and host of non-price and non-expenditure variables (demographics and quantities of other foods: also called conditional variables; habits, nutrition information and dietary beliefs and advertising: also called taste augmenting variables).

## Objectives

(1) to estimate posterior odds ratio for individual model dimensions (theoretical restrictions, taste augmenting variables, conditional variables, trend, and functional forms);

(2) to determine the need for more general theoretical structure, posterior odds ratio is calculated for eight increasingly general theoretical structures; they are (a) traditional model with no additional variables, (b) traditional model with time trend, (c) taste segmented traditional model, (d) taste augmented traditional theory with time trend, (e) conditional theory, (f) conditional theory with time trend, (g) taste augmented conditional theory, (h) taste augmented conditional theory with time trend;

(3) to estimate average price and expenditure elasticities over models or meta-elasticities;

(4) to use meta-elasticities to calculate changes in caloric intake as a result of 10 percent ad-valorem tax on sugar-sweetened beverages.

## Data

Non-alcoholic beverages considered in this study are soft drinks (this is the sugar-sweetened beverage considered), milk, fruit juices, bottled water, tea and coffee. Annual data from 1970 through 2010 will be used. Quantity and price data are obtained from USDA-ERS per-capita food availability and Bureau of Labor Statistics CPI detailed reports respectively. Conditional variables such as consumption of cereals, and fruits and vegetables, percentage children in the population, percentage of food away from consumption are obtained from USDA-ERS and U.S. Census Bureau. Taste augmenting variables namely, adult and childhood obesity rates (proxies for health information) are obtained from Centers for Disease Control and Prevention database. Advertising data are obtained from Leading National Advertisers and AdView (Nielsen group). Habits are measured by incorporating appropriate lag structure of quantity variable for each beverage.

## Methodology

We consider four popular functional forms: the Rotterdam model, first differenced Almost Ideal Demand System (AIDS) model, the Dutch Central Bureau of Statistics (CBS) model, and the National Bureau of Research (NBR) model. Let $E$, $q_r$, $p_r$, $w_r$ represent total expenditure on six non-alcoholic beverages, per capita quantity, price and expenditure share on the *r*th non-alcoholic beverage, respectively. The additional variable vector is defined as $\boldsymbol{X}^A = (x_1^a, x_2^a, \dots \dots x_{18}^a)$; $x_1^a, \dots x_6^a$ are advertising variables; $x_7^a, \dots x_{12}^a$ are lagged variables capturing habits; $x_{13}^a, x_{14}^a$ are adult and childhood obesity rates; $x_{15}^a$ is per capita cereal consumption; $x_{16}^a$ is per capita fruits and vegetable consumption; $x_{17}^a$ is percentage of children; $x_{18}^a$ percentage of food consumed away from home. The Rotterdam model: $w_{rt}Dq_{rt} = \mu_r DV_t + \sum_{s=1}^{6} \pi_{rs} Dp_{st} + \sum_{s=1}^{18} \theta_{rs} Dx_{st}^a$ where for any variable $z_t$, $Dz_t = \ln\left(\frac{z_t}{z_{t-1}}\right)$, $\mu_r$ is the marginal budget share for good *r*, $\pi_{rs}$ is the price parameter, $DV_t = (DE_t - DP_t)$ is the volume index, *P* is the Divisia price index and *t* is the observation; first differenced AIDS model : $w_{rt}Dq_{rt} = b_r DV_t + \sum_{s=1}^{6} \gamma_{rs} Dp_{st} + \sum_{s=1}^{18} \theta_{rs} Dx_{st}^a + w_{rt}DE_t - w_{rt}Dp_{rt}$; the CBS model $w_{rt}Dq_{rt} = b_r DV_t + \sum_{s=1}^{6} \pi_{rs} Dp_{st} + \sum_{s=1}^{18} \theta_{rs} Dx_{st}^a + w_{rt}DQ_t$; and NBR model $w_{rt}Dq_{rt} = \mu_r DV_t + \sum_{s=1}^{6} \gamma_{rs} Dp_{st} + \sum_{s=1}^{18} \theta_{rs} Dx_{st}^a + w_{rt}DP_t - w_{rt}Dp_{rt}$. We use the Bayesian Averaging of Classical Estimates Approach, described by Bryant and Davis (2008) in defining prior probabilities, calculating posterior odds ratios, meta elasticities accounting for model specification uncertainty and in the end changes in caloric intake as a result of 10% tax on soft drinks.

## Results and Discussion

We are in position to address the model uncertainty in multiple dimensions simultaneously; thereby calculate posterior odds ratios for various model dimensions as well as eight increasingly general theoretical structures. This will help us calculate elasticities (meta-elasticities) and caloric changes as a result of tax on sugar-sweetened beverages averaging over several models.

### References

American Beverage Association (2011)

Beverage Marketing Corporation, (2011)

Bryant, H.L., and G. Davis, 2008. "Revisiting Aggregate U.S. Meat Demand with a Bayesian Averaging of Classical Estimates Approach: Do We Need A More General Theory? American Journal of Agricultural Economics, 90(1):103-116

Dharmasena, S., O.Capps, Jr. (2012) "Intended and Unintended Consequences of a Proposed National Tax on Sugar-Sweetened Beverages to Combat the U.S. Obesity Problem." *Health Economics*, Published online in Wiley Online Library 2011 (wileyonlinelibrary.com). DOI: 10.1002/hec.1738

Pittman, G.F. 2004. "Drivers of Demand, Interrelationships, and Nutritional Impacts within the Non-Alcoholic Beverage Complex." Unpublished PhD Dissertation, Texas A&M University.

Sala-i-martin, X., G. Doppelhofer, and R. Miller. 2004 "Determinants of Long-Term Growth: A Bayesian Averaging of Classical Estimates (BACE) Approach." American Economic Review, 94:813-35

Ueda, T., and D.L. Frechette. April 2002. "Have Milk Fat Preferences Shifted? Structural Analysis of New York Milk Consumption." *Agricultural and Resource Economics Review* 31(1):71-83.

Uri, N.D. 1986. "The Demand for Beverages and Interbeverage Substitution in the United States." *Bulletin of Economic Research* 38(1):77-85.

Vartanian, L., M. Schwartz, and K. Brownell. 2007. "Effects of Soft Drinks Consumption on Nutrition and Health: A Systematic Review and Meta-analysis." *American Journal of Public Health*, 97(4):667-675.

Zhen C, Wohlgenant MK, Karns S, Kaufman P. 2011. Habit formation and demand for sugar-sweetened beverages. American Journal of Agricultural Economics 93(1): 175-193.