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

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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 risks in the United States are coupled with the 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 vary across 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 caloric intake 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 caloric intake. Numerous model specification issues have been addressed in the past literature: functional form, single equations and demand systems.

For 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 (BAE) method 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 on model specification uncertainty: (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 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.

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 \( q_i, p_i, w_i \) represent total expenditure on six non-alcoholic beverages, per capita quantity, price and expenditure elasticities of each model, respectively. The additional variable vector is defined as \( x_i = (x_{i1}, x_{i2}, \ldots, x_{in}) \). Such variables are capturing habits, \( x_{i1} \), are adult and childhood obesity rates; \( x_{i2} \) is per capita calorie consumption; \( x_{i3} \) is per capita fruits and vegetable consumption; \( x_{i4} \) is percentage of children; \( x_{i5} \) is percentage of food consumed away from home. The Rotterdam model: \( w_{i1} = \frac{\mu_i}{\sum x_{ij} \sigma_{ij}} \sum \frac{x_{ij}}{\sigma_{ij}} \ln(\frac{y_{ij}}{\mu_i}) \) where for any variable \( x_{ij} \), \( \sigma_{ij} \) is the marginal budget share for good \( x_j \), \( \sigma_{ij} \) is the price parameter, \( \mu_i = (\mu_{i1}, \ldots, \mu_{in}) \) is the vector price index, \( P \) is the Divisia price index and \( \ln \) is the observation; first differenced AIDS model: \( \mu, w_{1,2,3,4,5} = h_0 + h_1 \ln \sum x_{ij} \Delta y_{ij} + h_2 x_{i1} + h_3 x_{i2} + h_4 x_{i3} + h_5 x_{i4} + h_6 x_{i5} \), where \( \Delta y_{ij} \) is the model wti model \( w_{i1} = \frac{\mu_i}{\sum x_{ij} \sigma_{ij}} \sum \frac{x_{ij}}{\sigma_{ij}} \ln(\frac{y_{ij}}{\mu_i}) \) and NBR model \( w_{i1} = \frac{\mu_i}{\sum x_{ij} \sigma_{ij}} \sum \frac{x_{ij}}{\sigma_{ij}} \ln(\frac{y_{ij}}{\mu_i}) \) and NBR model \( w_{i1} = \frac{\mu_i}{\sum x_{ij} \sigma_{ij}} \sum \frac{x_{ij}}{\sigma_{ij}} \ln(\frac{y_{ij}}{\mu_i}) \). We use the Bayesian Averaging of Classical Estimates Approach, described by Bryant and Davis (2006) 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 sugar-sweetened drinks.

Methodology

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.

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. Price and quantity 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.

Results and Discussion


References

Senarat Dharmasena and Henry L. Bryant (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

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