On Taxing Sugar-Sweetened Beverages to Combat the Obesity Problem

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Background

Obesity among all walks of life is one of the most widely emphasized nutrition-related health problems in America today. According to the joint publication, "A Handbook on Obesity in America", sponsored by The Endocrine Society and The Hormone Foundation (2005), 127 million adults in the United States are overweight, 60 million are obese and 9 million are extremely obese. Nayga (2008) reported that recent obesity rates for men and women in the United States are 36.5% and 41.8% respectively. The overweight/obesity problem is not only an issue with adults but also with children and adolescents. The Centers for Disease Control and Prevention (2007) of U.S. Department of Health and Human Services report that from 1980 through 2004, the prevalence of overweight increased among children and adolescents in America.

In addition to environmental and genetic factors, the selection of food and beverages potentially may be a contributing factor to obesity. With the publication of the 2000 and 2005 USDA Dietary Guidelines for Americans, the role of beverages in the American diet received more attention. There is a very wide variation in beverages in terms of their energy (caloric) content and nutrient composition, ranging from zero-calorie bottled water to low-calorie diet soft drinks to heavily-caloric coffee drinks. Additionally, beverages provide nutrients such as calcium and vitamin C (viewed positively by health officials) as well as caffeine (viewed negatively by health officials) to the diet. Therefore, beverage choices made by individuals may potentially influence the quality of the diet.

The 2000 USDA Dietary Guidelines gave prominence to the role of soft drinks and other sweetened beverages on the U.S. obesity problem. The 2005 Dietary Guidelines reiterated the need to limit calories from soft drinks. It emphasized even more strongly than previously the need to increase consumption of non-fat and/or low-fat milk in lieu of carbonated soft drinks (Dietary Guidelines for Americans, 2000 and 2005).

According to the American Beverage Association (ABA) (2007), beverage manufacturers have responded positively to the changing needs and interests of consumers and public health policy makers by introducing low-calorie, zero-calorie, calcium-fortified, nutrient-enhanced and decaffeinated beverage choices.

Nevertheless, Brownell *et al*. (2009) maintain that consumption of sugar-sweetened beverages (SSB) (such as carbonated soft drinks, fruit and vegetable drinks, energy drinks, sports drinks, iced teas, iced coffees, flavored milk and dairy drinks) has been linked to obesity, diabetes and heart disease, and they make a compelling argument to reduce the consumption of SSB. Furthermore, the U.S. Senate Finance Committee (2009) suggested a Federal excise tax per 12 ounces of SSB as a revenue option to finance comprehensive health care reform. According to Brownell *et al.* (2009), the aforementioned tax policy has a two-pronged effect: (1) health benefits to the public through the reduction of the consumption of SSB; and (2) the generation of tax revenue to be invested in public health care. Brownell *et al.* (2009) claim that a tax of one cent per ounce of SSB, which would increase the cost of a 20 oz soft drink by 15% to 20%, would reduce caloric consumption by about 10%. Additionally, the aforementioned tax would generate $14.9 billion in the first year alone (Brownell *et al.*, 2009). Moreover, the Center for Science in the Public Interest (2009) using their liquid candy tax calculator claims that a Federal

excise tax of one penny per 12-ounce soda could generate more than $1.5 billion per year, providing notable expenditures toward health care.

The ABA opposes a tax on SSB, arguing that obesity is a very complex problem which should be addressed by way of a comprehensive nutrition plan such as nutrition education on balancing calories and not just a plain tax on SSB. Furthermore, the ABA states that such tax would “harm hard-working middle-income Americans”. Hahn (2009) estimated that 3 cents of excise tax on 12-ounces of SSB would increase prices by four to six percent which would ultimately reduce revenues to the beverage industry by $10 billion, resulting in the loss of approximately sixty thousand jobs.

Indeed a tax on a sugar-sweetened beverage would decrease the consumption of that particular beverage, all other factors invariant; but arguments in describing the ramifications of the proposed tax fail to consider demand interrelationships among various beverages. In other words, it is necessary to consider not only own-price effects but also cross-price effects due to the proposed tax. All parties concerned about the proposed tax on SSB have not taken into account the indirect effects of the proposed excise tax. We will explore both the direct (own-price) effect, and more importantly the indirect (cross-price) effect of excise taxes on SSB.

Objectives

We addressed the aforementioned problem using a complete demand systems approach. Specific objectives of this study are: (1) to estimate own-price and cross-price elasticities of selected non-alcoholic beverages; and (2) to estimate the direct and indirect effects of the proposed excise tax on SSB in terms of changes in consumption.

Specific categories of non-alcoholic beverages considered are isotonics, regular soft drinks, diet 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.

Data and Methodology

Initially, monthly household purchases of non-alcoholic 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 non-alcoholic beverage categories. As such, we generate monthly purchase data to arrive at a total of 72 observations for each non-alcoholic beverage category. Quantity data are standardized in terms of gallons per person per month and expenditure data are expressed in terms of inflation-adjusted dollars per month. We generated unit values (real prices) for each non-alcoholic beverage category by taking the ratio of real expenditure to volume.

We employed a linear approximation to the quadratic almost ideal demand system (QUAIDS) model developed by Banks, Blundell and Lewbel (1997) and Matsuda (2006) to capture interrelationships among ten non-alcoholic beverage categories. Expenditure, own-price and cross-price demand elasticities (both uncompensated and compensated) were estimated for the ten non-alcoholic beverage categories over the 72-month period. The calculated compensated own-price and cross-price elasticities were used to capture the direct and indirect effects, respectively, of the proposed excise tax on sugar sweetened beverages (we assumed the proposed excise tax was 20 percent).

Model Development

We posited the following linear approximated quadratic almost ideal demand system (LA/QUAIDS) model with an additive disturbance term and a seasonal adjustment done using quarterly seasonal dummies.

$$w_{it} = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln p_j + \beta_{it}\left[\ln m - \sum_{i=1}^{n} w_{it-1} \ln p_{ti}\right] + \frac{\lambda_i}{\sum_{i=1}^{n} (\overline{w}_{it-1} - \overline{w}^0_{it-2})(\ln p_{it-1} - \ln p^0_{it-2})}\left[\ln m - \sum_{i=1}^{n} w_{it-1} \ln p_{it}\right]^2 + \sum_{j=1}^{3} d_j Q_{ijt} + e_{it} \quad (1)$$

where i = (1,2,.....,10) indexes ten non-alcoholic beverages categories in the system, t indexes the time in months, i.e. t = (1,2,3,.....,72) p_{jt} is monthly real prices for each non-alcoholic 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 non-alcoholic beverage, q_{it} . Q_{ijt} is the quarterly dummy used to capture the seasonality pertaining to four quarters of the year. Monthly budget shares of each non-alcoholic beverage consumed is denoted by w_{it} where $w_{it} = \frac{p_{it} q_{it}}{m}$. The additive disturbance term is denoted by e_{it} .

In estimating the LA/QUAIDS model, we imposed following theoretical restrictions on parameters explained in equation (2) through equation (7) (adding-up, homogeneity and Slutsky symmetry).

Restrictions imposed are, adding-up,

$$\sum_{i=1}^{n} \alpha_i = 1 \quad (2)$$

$$\sum_{i=1}^{n} \beta_i = 0 \quad (3)$$

$$\sum_{i=1}^{n} \lambda_i = 0 \quad (4)$$

$$\sum_{i=1}^{n} \gamma_{ij} = 0, \quad (5)$$

where $j = 1,2,.....,n$

and homogeneity,

$$\sum_{j=1}^{n} \gamma_{ij} = 0, \text{ where } i = 1,2,.....,n \quad (6)$$

Slutsky symmetry conditions are satisfied via the restriction

$$\gamma_{ij} = \gamma_{ji} \text{ for } i, j = 1,2,.....,n \quad (7)$$

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 estimated the LA/QUAIDS 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 were recovered using adding-up restrictions.

The model was estimated using SAS 9.2 statistical software. Presence of possible autocorrelation (serial correlation) was examined through the autocorrelation and partial autocorrelation function. Calculated autocorrelation and partial autocorrelation functions of the residuals of all non-alcoholic beverages indicated the presence of possible serial correlation. A close study of these functions indicated the presence of second-order or third-order autoregressive process of disturbance terms in the system. Therefore, each system was fitted with first- second- and third-order autoregressive process of disturbance terms and the significance of

autocorrelation coefficients was examined. Through this exercise, we found that disturbance terms behave as an *AR(2)* process.

Results and Discussion

In the following section, first we discuss some summary statistics of the data we used in our study. Second, we elaborate the effect of an ad valorem tax policy on sugar sweetened non-alcoholic beverages taking only the conventional elasticity estimates.

Summary Statistics

Table 1 shows the summary statistics for quantity (per capita gallons/month), real price (dollars/gallon) and budget shares for the data used in this study. The most heavily consumed non-alcoholic beverage per month at home was coffee on per-capita basis (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 (for example Gatorade) was the least consumed non-alcoholic beverage at home, were only about 0.03 gallons per person per month.

Isotonics and fruit juices were the most expensive non-alcoholic beverages consumed during the period considered. They were, on average, $2.55 per gallon and $2.45 per gallon respectively. Coffee was the least expensive non-alcoholic beverage at $0.61 per gallon on average. The highest budget share is associated with consumption of regular soft drinks at home (20%), and the lowest budget share is associated with isotonics (1%). The average budget share for fruit juice stands at second highest. Per capita real total expenditure for all of the ten non-alcoholic beverages consumed at home was on average $1.82 per month.

Table 1: Quantity (per capita gallons/month), Real Price ($/gallon) and Budget Share Summary Statistics: January 1998 through December 2003

		Mean	Std Dev[1]	Minimum	Maximum
Per Capita Quantity gallons/month	Isotonics	0.03	0.013	0.01	0.06
	Regular soft drinks	0.91	0.126	0.66	1.24
	Diet soft drinks	0.56	0.060	0.45	0.72
	High fat milk	0.53	0.061	0.39	0.67
	Low fat milk	0.38	0.069	0.26	0.53
	Fruit drinks	0.23	0.037	0.15	0.29
	Fruit juice h	0.45	0.053	0.34	0.55
	Bottled water	0.35	0.072	0.19	0.52
	Coffee	0.93	0.128	0.67	1.15
	Tea	0.34	0.034	0.28	0.42
Real Price $/gallon	Isotonics	2.55	0.177	2.24	3.01
	Regular soft drinks	1.38	0.046	1.28	1.48
	Diet soft drinks	1.38	0.045	1.30	1.49
	High fat milk	1.60	0.061	1.49	1.76
	Low fat milk	1.59	0.057	1.47	1.74
	Fruit drinks	1.91	0.083	1.75	2.06
	Fruit juice	2.45	0.068	2.29	2.59
	Bottled water	0.78	0.049	0.66	0.86
	Coffee	0.61	0.064	0.52	0.75
	Tea	0.78	0.045	0.68	0.91
Budget Share[2]	Isotonics	0.01	0.004	0.01	0.02
	Regular soft drinks	0.20	0.013	0.17	0.23
	Diet soft drinks	0.13	0.006	0.11	0.14
	High fat milk	0.14	0.007	0.12	0.15
	Low fat milk	0.10	0.009	0.08	0.12
	Fruit drinks	0.07	0.009	0.05	0.09
	Fruit juice	0.18	0.013	0.15	0.20
	Bottled water	0.05	0.015	0.02	0.08
	Coffee	0.09	0.011	0.07	0.11
	Tea	0.04	0.005	0.03	0.05
	Per capita real total expenditure, $/month	1.82	0.122	1.49	2.06

[1] Std Dev is Standard Deviation
[2] Budget shares may not add up to one due to rounding.

Effects of an Ad Valorem Tax on Sugar Sweetened Beverages

Compensated own- and cross price elasticities for ten non-alcoholic beverages were used to generate direct (own-price) and indirect (cross-price) effects of an ad valorem tax of 20% on sugar sweetened non-alcoholic beverages. Isotonics, regular soft drinks, fruit juices and fruit drinks are considered to be sugar-sweetened beverages for this study. As a result of 20% ad valorem tax on aforementioned sugar-sweetened non-alcoholic beverages, the prices of those are expected to go up by 20 percent.

In the Table 2, we illustrate the direct, indirect and total percentage change in quantities as result of a 20% ad valorem tax on sugar sweetened non-alcoholic beverages (beverages considered as in sugar content are isotonics, regular soft drinks, fruit juices and fruit drinks).

Table 2: Direct, Indirect and Total Percentage Change of 20% Ad Valorem Tax on Isotonics, Regular Soft Drinks, Fruit Drinks and Fruit Juices

	direct effect % change in per capita Quantities	indirect effect % change in per capita quantities	total effect % change in per capita quantities
isotonics	-77.09	-1.957	-79.046
Regular soft drinks	-39.30	24.977	-14.327
Diet soft drinks	0.00	2.698	2.698
High fat milk	0.00	-5.487	-5.487
Low fat milk	0.00	9.261	9.261
Fruit drinks	-11.89	-1.540	-13.430
Fruit juices	-20.70	33.447	12.751
Bottled water	0.00	-3.397	-3.397
Coffee	0.00	21.045	21.045
Tea	0.00	6.638	6.638

According to Table 2, notice that 20 percent price increase in isotonics, regular soft drinks, fruit drinks and fruit juices would decrease the percentage quantity consumption of each by 77%, 39%, 12% and 21% respectively. If we pay attention only to the direct effect of the tax policy, we would see that there is a definitive reduction in the consumption of sugar sweetened

non-alcoholic beverages. Also, notice that if we concentrate only the direct effect, we do not observe any changes in the consumption of non-sugar sweetened beverages like diet soft drinks, high fat milk, low fat milk, bottled water, coffee and tea. Looking at the direct effect of the tax only, one can conclude that tax policy is effective in reducing the desired sugar sweetened non-alcoholic beverages and consumption other non-alcoholic beverages are not affected. However, this is a wrong conclusion. One should not forget that these non-alcoholic beverages are interrelated in consumption. Cross-price elasticities of demand capture the interrelatedness among non-alcoholic beverages.

Aforementioned interrelatedness would result in an indirect impact of a tax policy. In the Table 2, also we report the indirect percentage change in per capita quantities on non-alcoholic beverages as a result of an ad valorem tax on sugar sweetened non-alcoholic beverages. Notice that indirect changes of quantities of isotonics and fruit drinks are negative, further strengthening the desired effect of tax policy. However, indirect effect of regular soft drinks is positive. This is indicative of an increase in consumption of regular soft drinks as an indirect effect of tax policy. Notwithstanding, this indirect effect is not high enough to surpass the large direct negative effect, hence we observe a reduction of regular soft drinks consumption as a result of the tax.

Tax policy is not effective for the consumption of fruit juices. Indirect effect percentage change in per capita consumption for fruit juices is positive and higher than the negative direct effect. Consequently, a 20% ad valorem tax on fruit juices price would increase the consumption of fruit juices by twelve percent. Not considering the indirect effect of tax policy on fruit juices consumption would lead to wrong conclusions about the effect of tax.

Due to the interrelatedness among non-alcoholic beverages, also we observe a considerable change in consumption of non-sugar sweetened beverages as well. Diet soft drinks,

low fat milk and tea consumption would increase by 3%, 9% and 7% in per capita quantities. This is probably due the fact that, people substitute sugar sweetened non-alcoholic beverages to diet soft drinks, low-fat milk and tea. However, notice that as result of a tax on sugar sweetened non-alcoholic beverages, consumption of high-fat milk and bottled water drops by 5% and 3% respectively. Drop in consumption of high-fat milk may act as a favorable result considering the high calories high-fat milk could contribute to the diet. However, reduction in the consumption of bottled water is not a favorable result, because bottled water is considered an all-time health alternative since it does not contain any calories.

Conclusions and Implications

Total percentage changes in per capita quantities of isotonics, regular soft drinks, and fruit drinks were negative as a result of a twenty percent ad valorem tax. This result is indicative of a reduction of consumption of sugar sweetened non-alcoholic beverages as a result of a tax policy. However, fruit juices consumption did not decrease as a result of a tax, because the positive indirect effect of a tax policy surpassed the direct negative effect. Consumption of high-fat milk and bottled water decreased as a result of a tax on sugar sweetened beverages. However, consumption of diet soft drinks, coffee and tea increased as a result of a tax on sugar sweetened beverages.

Direct effects and indirect effects of government policy actions placed on non-alcoholic beverages were ascertained through findings of this study. For example, we have investigated the effects of currently debated Federal excise tax or sales tax on sugar-sweetened beverages using own-price elasticities, and cross-price elasticities calculated in our study. Not only government policy makers, but beverage manufactures and retailers could use interrelationships among non-alcoholic beverages revealed from our study to design and execute appropriate pricing strategies.

The bottom line, we have to consider interrelationships between beverages in designing policy and concentrate more may be on indirect effects than direct effects.

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